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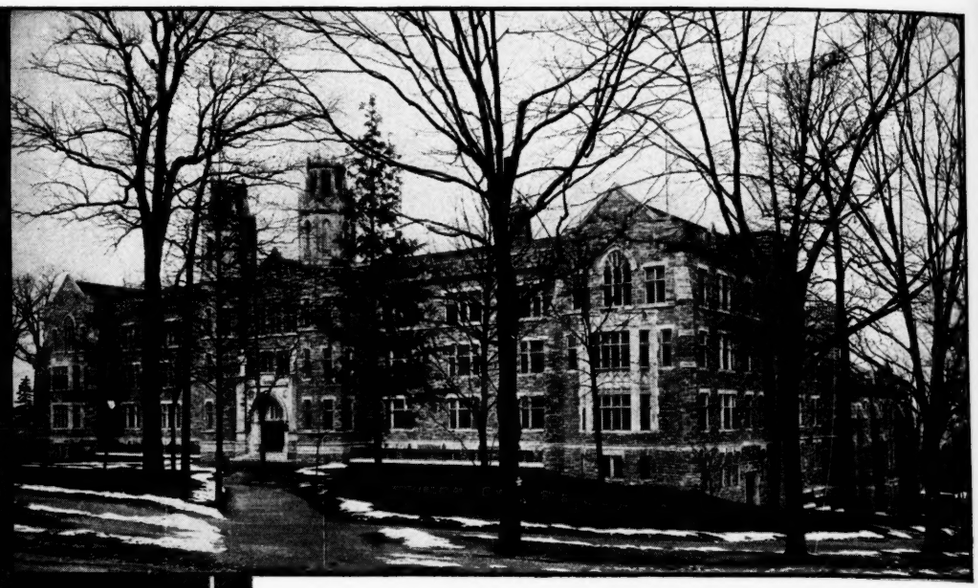

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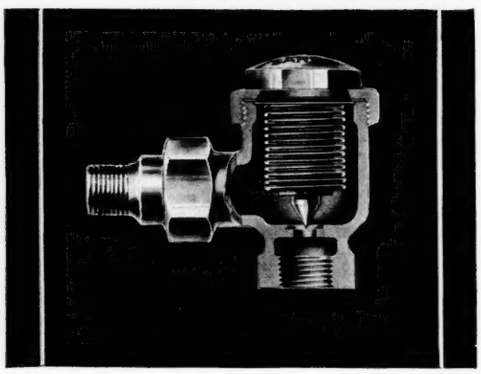

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EDITORIAL

Society Research—A Criticism and a Proposal

THE research undertaking of the A.S.H.V.E. is ten years old. Our attention was called to this recently by the receipt of a statement issuing from the secretary's office entitled "A New Era in A.S.H.V.E. Research Begins." We read the announcement carefully but could not seem to make the contents agree with the title. There seemed to be little in the announcement which would lead a careful reader to conclude that a new era was about to begin. The only new development so far as we could learn was that a technical advisor for research was to be engaged. Otherwise the old methods and the old organization were to be continued. Moreover, from a list of twelve subjects now under investigation and included in the text of the announcement,—all of which subjects bore a familiar look —we concluded that the old ideas of proper subject matter were also to be continued.

After reading the announcement in full we were distinctly disappointed. We had hoped from the title that a new era really was going to begin for we, in common with many other dues-paying members-in-ordinary, have watched the course of development of the research work with both wonder and astonishment.

We have watched it change from a comparatively minor interest until it dominates the activities to such an extent that the society has greatly changed in character as a result of having become the owner of a full-fledged laboratory and appurtenances.

We have watched the budget grow and expand. We have noted the extreme steps taken in attempts to increase the research activities. We have observed the almost grim determination to dominate research work in the field of heating and ventilation. We have seen the efforts put forth to convince the doubters, especially those outside the society, of the value and basic validity of some of the results obtained. We have seen the persistence with which certain subjects have been investigated and certain theories have been held. We have noted the continual tendency of the item of individual membership dues to fall off and of contributions and association funds to increase as proportionate totals in the research budget. We have seen the organized campaign for members carried on with the evident, even though unannounced, idea of swelling the funds.

We have followed, so far as possible from the published financial reports, the returns derived from the several activities into which the society has ventured as a body as a logical result of entering the research field and as a means of swelling the funds.

We have watched the growing power and exclusiveness of the governing bodies and management as the funds have grown. We have noted the usual "big-business" air with which their deliberations have become increasingly surrounded; the growing difficulty with which a simple, ordinary member can secure any information as to the inner workings. This is probably necessary where large funds are involved. At least it is a procedure in general use. As the funds have built up it has been necessary to more and more closely centralize control if large contributors are to be attracted.

All these developments we have watched and all the while our wonder has grown as to how long and to what extremes the evident tendencies may eventually be carried. Then we have tried to collect together our ideas as to the functions of a professional engineering society and have tried to reconcile them with the trend of events. We just can't seem to reconcile the two at all.

To our mind a professional society should be concerned with the individual interests of its members and should attempt to render individual service. It should pay attention to matters of professional conduct and ethics. It should serve as a meeting place where experiences can be freely exchanged. It should be essentially democratic both in its government and in its attitude. It should lend a helping hand to younger men just entering. Above all it should be dominated by a desire to improve the profession not alone for the present but for the future. Nearly every one who has given careful thought to the difference between a profession and a trade has arrived at the conclusion that the essential difference is that a profession looks upon itself as a trustee of the future, while trade is necessarily interested in immediate considerations, immediate applications, and immediate results.

We have no intention of denying that research work is a proper function of a professional society. No one is more in favor, or more impressed with the ultimate

value, of research work than we. We are, however, firmly convinced of two facts in this connection. First, that the research function should not be permitted to dominate the activities of a professional society to the virtual exclusion of others; and second, that the research work should at least have a professional, and not a trade, background.

As we look back over the research activities through the ten-year period we cannot help but reach the conclusion that these two facts have been almost totally disregarded in the research program.

Each year sees the several other activities of the society more and more dwarfed by the growing domination of the research work and its ramifications. Each committee seems to feel that it will be making a backward step if it fails to expand the research budget. Any available means of so doing is evidently considered fully justified by the results. To our mind this is decidedly open to question, and its wisdom should be frankly and openly discussed.

It seems to us that serious indictment may be brought against the past projects because of the imposition of an apparent rule to devote society funds only to projects yielding immediate results. The research programs have given too little consideration to basic investigations. Instead there has been a decided tendency to undertake those projects for which there is a present demand; too much of a tendency to use the research function to fill up holes in the *Guide* information; too much proneness to measure the results by the number of papers and reports submitted and by the size of the budget. We doubt greatly whether much of the information resulting from the past projects will stand the test of time in spite of their present timeliness.

We also feel that the limitation of the research work to laboratory investigations has been carried to ridiculous extremes, and that the same is true of its limitation to design data to the virtual exclusion of any systematic attempt to build up field data and operating results.

An illustration of the failure of the society program to take a professional attitude regardless of immediate application is not difficult to find. For years the accepted theory of the proper method of calculating building heat losses has been based on the assumption of a steady heat flow with stable terminal temperatures. This method evidently overlooks certain factors such as heat lag, heat capacity and rate of temperature penetration. This method is a heritage which the present generation received as a result of the professional activities of a past generation. Plenty of evidence is at hand to indicate that decided improvements can be made in the method. The problems are so involved, however, that actual working results may not be expected immediately. In spite of this condition being a matter of common knowledge the society program has taken but scant recognition of it. A professional attitude would have recognized its possibilities ere now, and would have caused more activity in the direction of discovering the essential data.

Other examples exist aplenty. Thus, if one were to use the research projects of the society as an index he would conclude that the phenomenon of the transfer of heat by radiant methods in building heating or cooling is of minor importance. He would also conclude that the society data on effective temperature constitute the last word. As a matter of fact there is another conception already in existence and under development but regarding which the research program of the society is totally blank.

When we considered all these points we were distinctly disappointed with the announcement that a new era was to be brought about by the simple expedient of appointing a technical advisor for research while continuing the former practices otherwise. We do believe that the appointment was wise, and that it may be made a first step in the beginning of a new era. Just how this will work out only time will tell. We are also quite certain that a really worthwhile new era cannot start until there is more concrete evidence of a realization of where the research activity is leading, and along what lines it should be directed. Perhaps one of the functions of the new advisor is to supply the advice on which this policy will rest. We are not sufficiently in the confidence of the management to know.

We firmly believe that even so his advice might very well be supplemented by that of others. A step has been taken in this direction by addressing a circular letter to the membership asking for proposals. To our mind this is not sufficient. We suggest that the present would be a most opportune time to appoint a committee to consider the whole matter of the past and projected research activities and policy. Moreover, we feel that this committee might very well be recruited from among the younger members of the society and that it should not be organized as a sub-committee of the standing committee on research. Rather it should be independent and should report directly to the membership at large.

Such a move at this time would do much to dispel the growing feeling among certain of the membership that the activities of the society are now in the hands of a small, self-perpetuating clique; that the interests of individual members are being subordinated to other considerations; and that full use is not being made of the talents of the membership.

Fig. 1. A combination counter and table service restaurant.

Air Cooling for Restaurants

By M. G. HARBULA†

RESTAURANTS are commonly classified both on the basis of the type of food service and on the character of the business during the day.

On the basis of type of food service, there are three classes of restaurants: (1) table service, (2) counter service, and (3) self-service.

On the basis of the character of the business during the day, restaurants are commonly classified as (a) one-meal restaurants, (b) two-meal restaurants, and (c) three-meal restaurants. In addition to these there are restaurants in certain localities where the patronage is practically continuous during the 24-hour period.

There is a considerable operating advantage in being able to spread the patron load over a long period, provided a reasonable patronage can be secured during the entire period. On the other hand, if the patronage is such that the restaurant can be closed a part of the day, while still maintaining a high ratio of patrons served per seat, some of the operating expenses can be reduced.

With such diversity it is practically impossible to generalize on the subject of air conditioning equipment or methods. Each restaurant has to be considered as an individual problem.

Physical Characteristics

It is interesting to note the relative density of seating which has been provided for in some successful restaurants. A high-class restaurant having table service provided one patron seat to every 20 sq. ft. to 30 sq. ft. of rented floor space. In such restaurants the actual space is divided about equally between that used for service and that used for tables. During the peak hours of the day every seat is normally occupied.

In a certain cafeteria, on the other hand, one patron seat was provided for every 15 sq. ft. to 25 sq. ft. of rented area and the ratio of the dining area to service area was about 1.2. While these figures are somewhat rough, they do show the general tendency of the table-service restaurant to spread its tables out somewhat rather than to crowd them close together.

Fig. 3 shows a general floor arrangement in a certain restaurant using table service. Fig. 2 shows an arrangement which has been widely used for counter-service restaurants.

In the main, restaurants are housed in rooms in buildings built for general purposes and in which the restaurant occupies only a small fraction of the total space. Very often, too, restaurants are located in rooms which were not primarily designed for such purposes. It is only in cases where it is definitely known that a restaurant will occupy certain quarters that it is possible to make arrangements for the cooling plant when the building is being laid out. As a consequence, many restaurants have to be adapted to the physical surroundings as they find them, and the same is true of cooling equipment.

In the main, also, restaurants are located either on ground floors or in basements, although there are outstanding exceptions.

Another point in connection with the physical characteristics of restaurant rooms is that very often they are open to the street and to outside walls, either at

† Consulting Engineer, Glen Ellyn, Ill.

one end only or else at both front and rear. Where so located the room is often relatively long and narrow with a ceiling of only normal height, namely 10 ft. to 15 ft. This is especially true where restaurants are located in rooms which were originally intended for general retail purposes.

Since there are such wide differences in the physical rooms occupied, no general plan is possible in arranging for floor layouts. However, several principles are in use. One is that cooking and service facilities and apparatus are commonly as closely combined as possible in order to give a maximum of space for dining purposes as against service uses.

Ceiling heights and the shape of the cooled space are important items, since they largely govern the details of the air distribution plans and may affect the selection of the minimum entering air temperature.

Restaurants catering to a high-class trade, such as those operated in hotels as main dining rooms, have ceiling heights of 18 ft. and over. They are usually of square shape or rectangular approaching a square.

Medium-priced restaurants, including cafeterias on street levels and hotel coffee shops, have approximately 14 ft. average ceiling heights. Some stores remodeled for restaurants of this type have ceilings as high as 20 ft, with the rear portion, and sometimes one or both sides, divided into mezzanine or balcony dining spaces. The shape of such restaurants is usually long and rectangular, with two or three aisles.

Department store restaurants are somewhat similar, but heights are of store standard from 12 ft. to 14 ft.

Basement restaurants, whether of the cafeteria or service type, may have ceiling heights as low as 9 ft.

Sandwich shops are perhaps the smallest type of restaurant. Ceiling heights average about 10 ft. to 14 ft. Shapes are mostly square.

Lunch rooms are often located in store spaces. Such stores selected and remodeled for restaurant purposes usually have comparatively high ceiling heights averaging 14 ft. and upwards.

Load Characteristics

One peculiarity of a restaurant cooling plant is the short annual period of its necessary operation and the shortness of its daily peak load. Since the magnitude of the peak is sharply dependent on the patron density there are peaks at the meal hours when the occupancy is greatest.

Hotel dining rooms in large metropolitan centers have their maximum patron occupancy in the evening between 6 p.m. and 8 p.m. The number served during the noon lunch period in such restaurants approximates 50% of the patrons dining in the evening, and the peak lasts about one and one-half hours. Breakfast patrons are fewest in number, averaging about 15 to 30% of evening diners.

Restaurants located close to shopping districts, office buildings and theaters in large metropolitan centers enjoy two peaks a day, the mid-day lunch period and dinner, the peaks continuing for about two hours. Some, in addition, specialize in after-theater luncheons. The number of patrons at that hour, however, constitutes perhaps only 50% of those at the noon or evening meal, and the peak lasts about an hour.

Restaurants located near apartment residential districts have their peak in the evening from 6 p.m. to 8:30 p.m. Such restaurants as a rule have no breakfast trade and only a light luncheon attendance.

Wide variations in the peak loads and in their duration and time of occurrence show how important it is that a careful study of the load characteristics be made.

A restaurant having a capacity patronage during one meal a day would have its cooling plant in operation at full capacity not more than three hours out of twenty-four, and if it were used for 100 days per year, the total operating period would be but 300 hr. While it may be desirable to keep a restaurant cool during the whole summer season, the fact remains that the number of days when operation is actually necessary is considerably less. Some owners feel that out of the entire summer there are about 30 to 60 days when outside weather conditions border on the unbearable, which means 90 to 180 hr. of necessary cooling plant operation in a restaurant having a one-meal peak load. With a two-meal peak per day this would amount to 180 to 360 hr. of operation. On a basis of continuous operation this would be 7½ to 15 full days at full load in a year. Such a plant would be idle, or operating at part load, 96% of the time. The first cost of the equipment is of the greatest importance when operated for such a small portion of the time. Careful analysis is necessary to determine what methods and apparatus are justifiable under these circumstances.

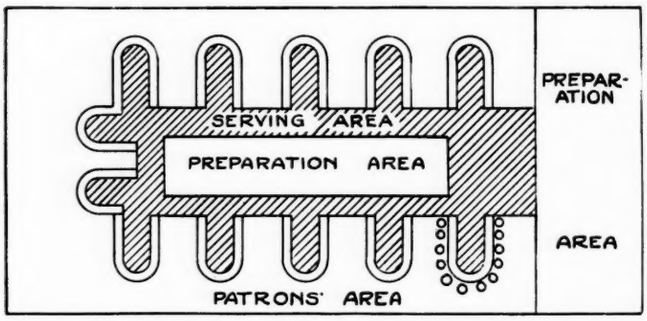


Fig. 2. A typical counter service layout.

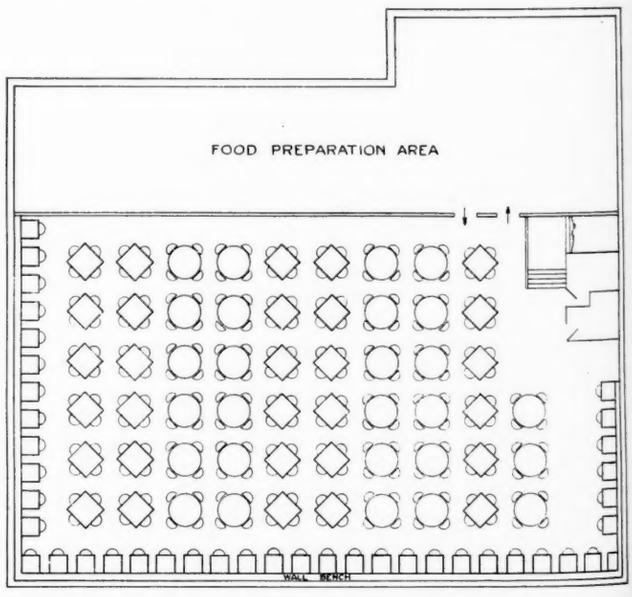


Fig. 3. Layout of a table service restaurant.

Restaurant Peculiarities

A variety of special considerations arise that make a restaurant cooling installation distinctive. Among these are the heat and moisture load due to food and to gas burners, electric grilles, steam tables, urns, and warming pans, which loads must be considered if the apparatus is located within the restaurant proper. The various auxiliary ventilating systems for the kitchens and ventilating hoods over cooking equipment within the restaurant must be properly coordinated and balanced with the air conditioning plant.

Another peculiarity is that while it is often urged that the meal checks per person may be expected to be larger due to a patron eating more in a cooled restaurant on a hot summer day than in one not cooled, this must be balanced against the fact that a patron can also be expected to occupy his seat longer, thus depriving another patron of a seat. No trustworthy data are in existence showing to what extent these factors counter-balance each other. A rapid eating rate per patron is often greatly to be desired from the standpoint of the owner.

Air Cooling Methods

Two general methods of securing the cooling of the air are in use, and a selection must be made between them. In the one the air is cooled by circulating it over or through a cold-substance or surface located inside the room itself. In the other the air is cooled at a central station commonly located outside the cooled space. The first is the "unit" method and the second is the "central station" method. In either case the cooling agent may be kept cold by the use of either ice, mechanical refrigeration or cold well-water.

Individual cooling units are available in both the dry pipe and the spray type. Wall fans conveniently spaced, and with which many restaurants are already equipped, aid in the circulation and distribution of the cooled air. The cooling apparatus which cools the medium circulated in the cooling units may be installed in any space adjoining the restaurant proper such as the basement or kitchen. The availability of standard units permits immediate installation in a period of a few days rather than requiring weeks or months. Units require but little space and, as a rule, little or no building changes to accommodate them. Low first cost results both from this elimination of changes and from the low first cost of the units themselves. When units are properly planned, selected and installed they have proved successful. They are especially adapted for use in existing restaurants.

Central station plants for cooling the air very commonly employ a water spray apparatus for the purpose. Distributing and transmission ducts lead to and from the cooled space and outlets must be designed and arranged to secure a suitable distribution of the air. Such plants often can be so arranged as to take up no floor space in the restaurant. While they may be, and are, installed in existing restaurants, this method lends itself particularly to use in new buildings.

The problem of finding sufficient space in an existing restaurant for cooling and air handling equipment is a serious one. Space is at a decided premium, with every nook and cranny used for some important restaurant function or for equipment that "cannot be spared." However, if a cooling plant is sufficiently desired, or if the business demands it, space can always be found by the ingenious designer.

The development of units has helped to solve this difficulty to some extent, particularly as regards the air handling equipment, but it must be kept in mind that the use of these units often makes it necessary to sacrifice some floor space in the restaurant.

Considerable progress has also been made in this direction in central station conditioners used with mechanical refrigeration. Such machines with self-contained cooling coils are now being manufactured to specifications in overall lengths of as little as 8 ft. 6 in. in the direction of the air flow instead of 15 ft. to 25 ft. which was common practice but a few years ago. Standard dehumidifiers, or "air conditioning machines" as the author prefers to call any machine that conditions air, were formerly always built 9 ft. long, *without coils*.

Either the unit or central station method permits the control of temperatures and humidities, and either may be so arranged as either to recirculate air or not.

The choice of the type for use in a particular case is simple as a matter of principle but difficult in the details. Adequate consideration should be given to all the factors involved. Particular attention should be paid to the items entering into the first cost in order to be sure that all are included. In an existing building this cost will include cost of foundations and excavating; cutting of holes through walls, ceilings, floors, etc., for equipment and ducts; electrical wiring for new motors; piping for new heaters and coolers; new city water and sewer connections for condensers and other water-carrying equipment, new grilles and other plaster work, and the painting and decorating both of equipment and restaurant where existing finish has been disturbed.

In new buildings most of these same items will be present, but there is much less likelihood of their being overlooked.

About the only sound procedure is to make tentative layouts covering each method and to analyze their respective first costs separately in order to arrive at a conclusion.

The Cooling Agent

Three means of cooling the air are available for use as follows: (1) mechanical refrigeration, (2) ice, (3) well water. Of these either of the first two can ordinarily be obtained in most localities. Well-water cannot always be secured in either sufficient quantities or at a low enough temperature. The choice is governed almost altogether by cost, since exactly the same ultimate results can be had with any of the cooling agents.

Use of mechanical refrigeration necessitates the purchase and installation of a complete plant including compressor, motor, condenser and evaporator. It has the advantage of making the production of the cooling effect independent in a complete plant. First cost of such a plant is high. Operating costs include the salary of a licensed operator, since one is often required.

The space problem where mechanical refrigeration is used is often difficult of solution. Local ordinances governing the installation of refrigerating plants in oc-

cupied places make the space problem more acute, for only certain spaces meeting the requirements of such codes may be used. It may even be necessary to remodel existing spaces to conform to some codes.

Cooling plant equipment is made by a number of manufacturers in a variety of types to fit into almost any kind of space available. For example, refrigerating compressors of the reciprocating type can be obtained in single or multi-cylinder, vertical or horizontal, and single or double acting. Drives may be direct-connected motors, long center belts or short center cog or V-belt drives. Condensers of the double pipe type are sufficiently flexible in arrangement and length to be installed either on the floor, on side walls, on ceilings, or over other equipment. They are also available in either the shell and tube or multi-tube type.

Cooling coils are now generally installed inside the central air conditioning machine, instead of being arranged as baudelot coils in a separate chamber with attendant showering apparatus. Use of such coils sometimes requires an extra water circulating pump as levels are not always favorable for gravity showering.

Recent developments in refrigerating equipment are the rotary compressor with direct connected motor, shell and tube type condenser, and shell and tube type water coolers. Such equipment may be installed with each individual element separate from the other and in the space available. However, certain definite heights or levels must be maintained between the several elements.

Another refrigerating machine is one using a centrifugal compressor with shell and tube type condenser and water cooler all in one unit on the same base. This is essentially a complete unit and must be installed as such, requiring a definite floor area and height which cannot be modified.

Space conditions are rarely so favorable that both the refrigerating machinery and the air handling equipment can be installed adjacent to each other. The resulting separation may add to the costs of piping and insulation.

Ice is proving to be a most economical cooling agent and appears well suited for the purpose. The ice used is the regular manufactured product of the ice manufacturer, or natural ice if available. It can be used in any form, whether block or broken. The only requirement is that it be frozen water. Such ice is obtainable at attractive prices in some localities.

Use of ice eliminates the largest and most expensive item making up the first cost of a cooling plant, namely, the refrigerating apparatus. Instead, this extensive apparatus is installed in a location remote from the restaurant itself. The attendant noise and vibration caused by refrigerating machinery in operation is entirely eliminated from the restaurant. A licensed engineer is not required. Refrigerants and lubricating oils for refrigerating machinery are eliminated entirely. A heavy investment is not tied up in refrigerating machinery which is idle for a considerable part of the year. Ice can be purchased and delivered as required, depending upon the weather or the number of patrons in the restaurant.

Ice can be used in connection with a cooling plant equipped with either individual unit coolers or with a central station cooling plant. The latter needs a fan or fans for supplying the air from the central point, an air cooler, ice storage and melting equipment, water circulating pump, a system of supply and return ducts for distributing the air in the spaces to be cooled, and the necessary control equipment for maintaining automatically the required or desired temperatures and humidities.

If water from artesian wells is available in sufficient quantities and at proper temperatures it may be used in such a plant instead of ice.

As in making any engineering decision where a selection of method on a cost basis is involved, the most suitable means is to set up tentative layouts covering each of the proposed plans, collecting full and itemized information on each. Care must be exercised that the cost estimate for each method includes all the items of both first cost and operating costs. Where such a cost study is made the selection of method is relatively simple.

British Researchers Invent Sunshine Recorder

A PATENT has been taken out by the British Department of Scientific and Industrial Research for a new sunshine recorder invented in the Building Research Station, Watford, during investigations into the heating requirements for a small house. It is claimed that the recorder will register hours of medium or low sunshine as well as those of high intensity.

For the new instrument a special type of differential ether thermometer has been developed. In appearance the instrument consists of a U-shaped tube, each leg of which ends in a cylindrical bulb of thin glass, the exterior of which is copper plated. One of the bulbs is painted black and the other, wound with a 10-ohm coil before being plated, is painted white. Into the glass of the thermometer are fused three platinum contacts. Two of them, close together, one above the other, are fixed into the leg below the black bulb, and the third into the other tube leg at the bulb base.

When the sun shines heat is absorbed by the black bulb, the ether in it expands, the mercury sinks, the upper contact in the black bulb is opened, and a 50-cycle alternating current from 200-volt mains is fed through a 2-microfarad condenser, by way of the mercury in the tube, to an electro-magnet which withdraws a stop action in the clock. A further depression of the mercury by about 1/32 in. opens the second contact, causing the current to flow through the heating coil around the white bulb, and maintaining the latter at practically the same temperature as the black bulb. The operation of the heating coil produces an almost imperceptible pulsation of the mercury surface for a period of about five seconds. When the sun ceases to shine the upper contact is rapidly made and the clock is stopped.

Application of Centrifugal Fans

A method of selecting the proper fan for a given application by the use of new characteristic curves and diagrams which can be developed mathematically.

By CHAS. A. CARPENTER

WHEN the average engineer attempts to solve a problem involving the use of fans, he encounters difficulties that would not exist if he observes certain fundamentals, and if the representative fan manufacturers would adopt a more rational method of presenting data.

In order to develop a method by which fans might be compared, the writer presented a paper before the Engineers Society of Western Pennsylvania, entitled "Applications of Centrifugal Fans."[1] Much of the material of this article is quoted or revised from that paper.

Two outstanding relations apply to fans within the scope of ordinary practice as generally observed.

For any fixed point of operation—as, for example, normal rated capacity at maximum efficiency — the pressure produced is a function of the tip or rim speed and the density of the gas handled.

This may be expressed thus:

$$X = \frac{\pi d N}{12 \times 4005 \sqrt{P}} \qquad (1)$$

[1]Proc. Engineers Soc. of Western Penna., Vol. 46, No. 8, pages 264-294.

SYMBOLS

K = specific speed. A mathematical term.
N = revolutions per minute.
C = cubic feet delivered per minute.
P = pressure in inches of water gage corrected to dry air at 70°F. and 29.92 in. of mercury.
E = efficiency.
E_t = efficiency based on total pressure.
E_s = efficiency based on static pressure.
d = diameter of fan wheel in inches.
w = algebraic average width of fan wheel in inches.
X = ratio of tip or rim speed to theoretical air speed corresponding to water gage corrected to dry air at 70°F. and 29.92 in. of mercury.
X_t = ratio based on total pressure.
X_s = ratio based on static pressure.
y = volumetric efficiency of the fan, or the ratio of air delivery per revolution to the cubical contents of the wheel.

Also,

$$C = \frac{\pi w d^2 y N}{6912} \qquad (2)$$

By simple algebra, $$y = \frac{6912 C}{\pi w d^2 N} \qquad (3)$$

From a theoretical consideration of these formulas many conclusions may be drawn. Since it conforms to general practice and is confirmed by tests published so far, that fans of identical design have definite ratios, X, of tip speed to theoretical air speed corresponding to the pressure produced (when due correction is made for temperature, barometer, humidity and other factors affecting density) and such fans have definite corresponding volumetric efficiencies, y, fan tables may be prepared by calculation of various standard sizes based on tests of one or more fans of the same design.

Hence, if a fan be tested, a fan twice as large operating under similar density conditions at the same number of revolutions per minute, N, and at the same relative efficiency would be expected to deliver eight times the volume at four times the pressure. Furthermore, the outlet area would be four times as great. The outlet velocity, therefore, would be twice as great and the outlet velocity head, varying as the square of the velocity, would be four times as great.

It will be noted that the relations between actual pressures produced—either total or static to the outlet velocity heads—do not vary. In other words, in present practice, the ratios of static pressures are functions of basic design and relative points of operation. These ratios are assumed to be independent of size of fan and density of gas handled.

These conclusions have led to the use of characteristic curves to explain fan performance. Such curves may show actual definite tests or may be converted to a percentage basis usually showing the variation in total pressure, static pressure, horsepower, efficiency, and ratio of static to total pressure plotted as ordinates against percentages of rated volume as abscissae.

Unfortunately such curves, while quite complete in themselves, do not solve the real problems of application and much more definite means should be provided to help engineers. It is the purpose of this article to show how new characteristic curves and diagrams can be developed mathematically to help engineers without in any way deviating from the science of fan engineering as known today, and yet being sufficiently flexible to permit adaptation to an improved fan technique.

The author wishes to stress the point that this paper takes science as accepted by fan builders and users, but shows how to apply this science easily and correctly in solving a problem of fan application. It may be said that this is now being done. Only a cursory glance is necessary to convince an observer that often fans are wrongly applied or are very inefficient. This applies to mines, steel mills, power houses, public buildings, and the other myriad uses of machinery to force or to draw gases into circulation.

While this statement may sound like an exaggeration, analysis of fundamental fan relations as published at present reveals the cause. At any constant speed for a given design and size of fan, the relation between the quantity C in cubic feet per minute delivered, and the pressure, P, developed, may be shown by a line curve known as the fan characteristic. For an airway of unchanging dimensions and unchanging surface another definite relation exists between the quantity C and the pressure P. This, as generally stated, is that the pressure varies as the square of the volume or velocity. Some deviation from an exact parabola may occur due to changes of temperature through air travel, etc.

A centrifugal fan, therefore, must perform at the one point where the curve of airway relationship intersects the fan characteristic at any instant. If this intersection does not occur where fan efficiency is reasonable (near the point of best efficiency), a loss occurs that may reach enormous values. It is also possible that the fan may fail miserably in its service by delivering much less volume than required.

Two formulas may be developed to summarize fan performance. These are:

$$K = \frac{N\sqrt{C}}{79.72p^{3/4}} \qquad (4),$$

and

$$K = 505.98\,X^{3/2}\sqrt{\frac{wy}{d}} \qquad (5).$$

The formula (4) shows the specific speed required by the job. Formula (5) shows the specific speed based on fan design. In operation the two formulas must be identical.

For eighteen years the author has been using specific speed in connection with pumps and fans. Many tables of fan performance have been analyzed with the result that some general conclusions may be drawn as to standardized fan performance. Most performance tables of fans of any given design are based on the following assumptions:

1. The volumetric efficiencies may be computed from cubic feet per minute, wheel dimensions, and revolutions per minute.

2. Corresponding to a value of volumetric efficiency, y, there are definite values of ratios X_t and X_s and efficiencies E_t and E_s.

3. These relations are independent of N, wheel dimensions d and w, and revolutions per minute.

That these statements are not absolutely true must be evident, but within ordinary operating speeds of fans of standard design they are probably as nearly correct as can be determined by ordinary current methods of fan testing. Undoubtedly, a very wide variation in revolutions per minute would reveal considerable variation in efficiency and any great change in dimensions would show variations in performance.

Taking these relations as being virtually true as commercially used, we can draw many interesting conclusions from the formulas (4) and (5).

Since the number of cubic feet per minute, C, and the pressure, P, are determined by conditions surrounding any job, the specific speed, K, can be varied only by changing the revolutions per minute, N. This clearly accounts for the desire on the part of manufacturers featuring standardized designs to select their own speeds. As a result, many expedients are in vogue.

Fans may be driven indirectly by belts, chains, gears, etc., in order to obtain selected speeds. Variable-speed motors may be suggested in order to mask the limitations of any particular design. In such cases the fan may be designed to operate well below the maximum motor speed. Steam drives are still used because speeds may be chosen to fit the standard fan design.

Considering formula (5) it is evident that all features of a good design may be preserved if K may be set by the fan manufacturer. However, problems are arising with increasing rapidity in connection with centrifugal machinery in which K is fixed by conditions beyond the control of the manufacturers of centrifugal machinery.

Many years ago water turbine builders faced this problem and "specific speed" became a tangible fact to them. If we consider that water power is available in varying volumes and heads but that speeds of the driven generators are quite limited, it is readily seen why water turbine designers analyzed their problem.

During the past fifteen years, belt-driven centrifugal pumps have nearly disappeared but indirectly-driven fans predominate.

Approaching the problem solely from the viewpoint

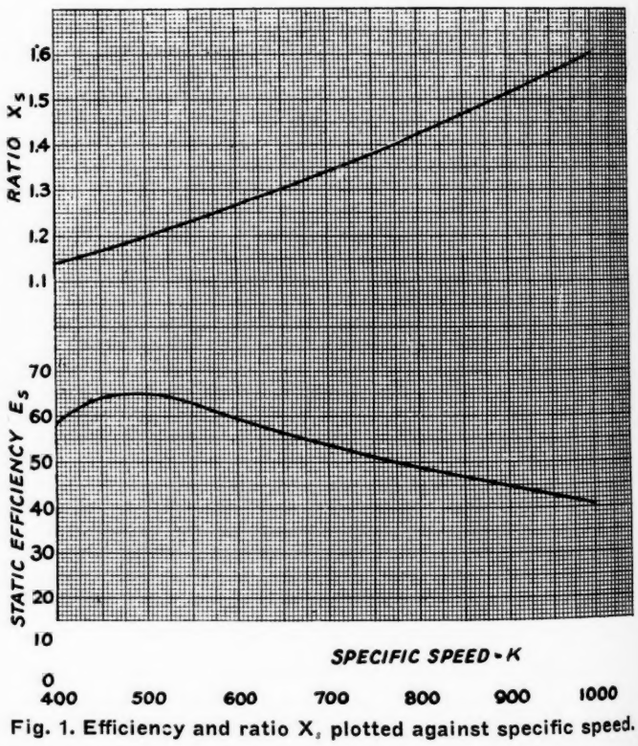


Fig. 1. Efficiency and ratio X_s plotted against specific speed.

of fan manufacture, let us examine formula (4). We have three variables as follows:

X = ratio of tip speed to theoretical speed of air corresponding to water gage corrected to dry air at 70°F. and 29.92 in. of mercury.

y = volumetric efficiency expressed as a decimal.

$\frac{w}{d}$ = ratio of average width of wheel to diameter.

It has been stated that within the limits of ordinary fan practice X and y are fixed for any design for any specific condition such as no delivery, 20% of full open delivery, free delivery, etc., and for each of these conditions definite efficiencies are obtained (approximately) regardless of revolutions per minute or wheel diameter. For no delivery, y = O, E = O, X depends on design. For free delivery, X_s = infinity, E_s =O, y depends on design.

The relation $\frac{w}{d}$ appears offhand to offer the easiest method of varying specific speed, therefore we find many fan builders offering fans of one type and wheel diameter combined with two or more widths. There are limits, however, to the value of $\frac{w}{d}$ if efficiency is to be maintained. Wide wheels necessarily have relatively restricted inlets, while very narrow wheels have high friction losses through the wheel and due to the exposed sides of the wheel. Since the variation of K is as the square root of $\frac{w}{d}$ the ultimate range of specific speed due to permissible variations in wheel width is comparatively small.

Varying X and y has fascinated fan designers for many years; hence the many odd-shaped blades, inlets, wheel tapers, scrolls, etc. The disappointing phase of this history is the fact that for good efficiency with various prevalent designs X goes down when y goes up, thus largely keeping these two factors in balance.

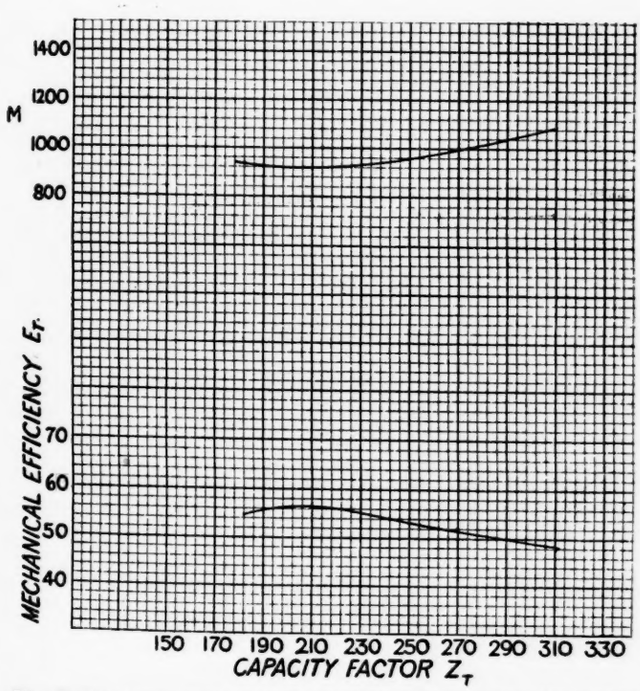


Fig. 2. Efficiency and ratio M plotted against capacity factor.

The product Xy which we shall call capacity factor Z has interesting algebraic possibilities.

$$Z = X\,y = \frac{576\,C}{d\,w \times 4005\,\sqrt{P}} \qquad (6)$$

Capacity factor Z takes into consideration the following:

Capacity in cubic feet per minute, C.

Pressure in inches of water gage, P, corrected to dry air at 70°F. and 29.92 in. of mercury.

Diameter of wheel in inches, d.

Width of wheel in inches, w.

Since for any correlated values of X and y, there are corresponding values of efficiency, E_t and E_s for a given design, performance curves using Z as a base and values of E as ordinates may be plotted.

Fig. 1 shows some representative curves with values of K as abscissae and corresponding values of E and X as ordinates.

Fig. 2 shows curves using Z (capacity factor) as abscissae and corresponding values of E and X as ordinates.

It is to be hoped that fan manufacturers will cooperate with their customers by publishing charts of performance of their various designs plotted as in Figs. 1 and 2. Engineers interested in fan applications could then aim to keep specific speed within desirable limits and could check capacity factors Z from the required capacity, pressure and wheel dimensions. This method would completely solve fan problems involving choice of speed by the fan manufacturer. It would also turn the light on the engineering investigation yet necessary to offer to the trade truly efficient direct-connected fans that would be comparable with modern centrifugal pumps.

In order to visualize fan performance in a broad way, the author has developed charts from the following algebraic analysis:

$$\text{Since capacity factor } Z = \frac{576\,c}{d\,w \times 4005\,\sqrt{P}},$$

$$\frac{c}{\sqrt{P}} = \frac{4005\,Z\,d\,w}{576}$$

Since Z varies from 0 to some maximum desirable limit for each type of fan, a chart may be prepared showing standard values of d; w being a function of d with Z as abcissae and $\frac{c}{\sqrt{P}}$ as ordinates.

Fig. 3 shows radiating lines with wheel diameters given in feet with scale for a value of 0.5 for w/d.

On this diagram, the Z (capacity factor) scale can be changed for other values of w/d by simple arithmetic, the scale changing inversely as the ratio w/d. Thus if w = d, w/d = 1.0, and when compared with Fig. 3, which is based on w/d = 0.5, the Z scale should be half of that shown. Where a Z value of 50 is shown for w/d=0.5, a Z value of 25 would be used for w/d=1.0.

Likewise a diagram may be prepared showing C equal cubic feet per minute as abcissae, $\frac{C}{\sqrt{P}} = L$ as ordinates, and P in various values of diagonal lines. This

curve is not shown because $L = \frac{C}{\sqrt{P}}$ is so readily figured on a slide rule.

In Fig. 2 are shown Z — E and Z —X curves, which are also based on a Z scale for w/d = 0.5.

Since $X = \frac{\pi d N}{12 \times 4005 \sqrt{P}}$ we can let $M = \frac{12 \times 4005 X}{\pi} = \frac{d N}{\sqrt{P}}$

whence $N = \frac{M \sqrt{P}}{d}$

This permits further graphical solution by drawing lines for various values of P with dN as abscissae and M as ordinates.

This is shown in the upper part of Fig. 4 with camouflaged scales for M and dN corresponding to the marked M scale in Fig. 2.

A diagram may also be constructed showing standard values of d with dN as abscissae and N as ordinates. Such a diagram is shown in the lower part of Fig. 4.

It should be pointed out that for the purposes of this article no attempt has been made to have the scales for capacity factor Z and dN depict actual fans.

The general use of these diagrams will now be shown.

For solving problems of adjustable speed fans, C and P being known, $\frac{C}{\sqrt{P}}$ can be computed. A suitable efficiency taken from Fig. 2 fixes an approximate location of Z, and using Fig. 3 the nearest correct value of d is obtained. This, in turn, fixes the value of Z when the $\frac{C}{\sqrt{P}}$ horizontal line intersects the selected d radial line. The value of Z fixes a value of M directly above the aforementioned intersection.

In Fig. 4 reading horizontally across from the M scale to the required pressure P fixes a value of dN. Dropping vertically down to the chosen wheel, diameter d fixes a value of N which is the required revolutions per minute of a fan of d diameter to deliver the required volume efficiently at the required pressure.

Only a few minutes are required to learn if a smaller fan at a higher speed may be sufficiently efficient to be a good purchase.

It is also evident that a rapid selection may be made for a standard fan that would best meet performance for variable service between major and minor values of $\frac{C}{\sqrt{P}}$. In fact, from Figs. 2 and 4, such operation as to efficiency may be seen at a glance and only a few seconds are required to determine the range of speed.

One of the most important features of proper fan selection is to provide for the probable range of actual operating conditions because calculations of air problems rarely suit actual performance.

In order to solve problems of fixed speed, a different procedure must be followed.

From Figs. 3 and 4, it is readily seen that the diameter of the fan must lie between certain limits if good efficiency is to be obtained when delivering volume C at pressure P.

From the determined revolutions per minute, using the lower part of Fig. 4, intersections with the tentatively selected diametric lines, when projected vertically upward to the required pressure line, fix values of M.

Values of M below the range of the chosen fan, as given in Fig. 4, indicate that the fans selected are too small.

Having found a fan size that will perform at the given pressure and revolutions per minute, the intersection of the required value of M and the Z — X curve locates Z the capacity factor. On Fig. 4, the intersection of the value of Z and the selected fan size fixes the value of $\frac{C}{\sqrt{P}}$ when C may be determined.

To fulfill the requirement, C must not be less than the specified capacity and as close to this required volume as can be met by a standard fan.

If the specifications are absurd, as many fan inquiries are, it may be expected that speeds will be required that make it absolutely impossible with existing designs to have a proper installation. It is for this very reason that the writer advocates the new diagrams. Engineers having access to such curves would naturally draw better specifications, at least as far as fixed speeds are concerned.

In this connection, it should be noted that proper use of the formula (4) for specific speed based on performance also shows limits of available revolutions per minute to give good efficiency.

The author hopes that fan manufacturers will cooperate with engineers by adopting a standard scale diagram combining the diagrams of this article. Such a combined chart would enable any engineer to make a quick survey of existing designs and he could select the type or types most suitable for his problem.

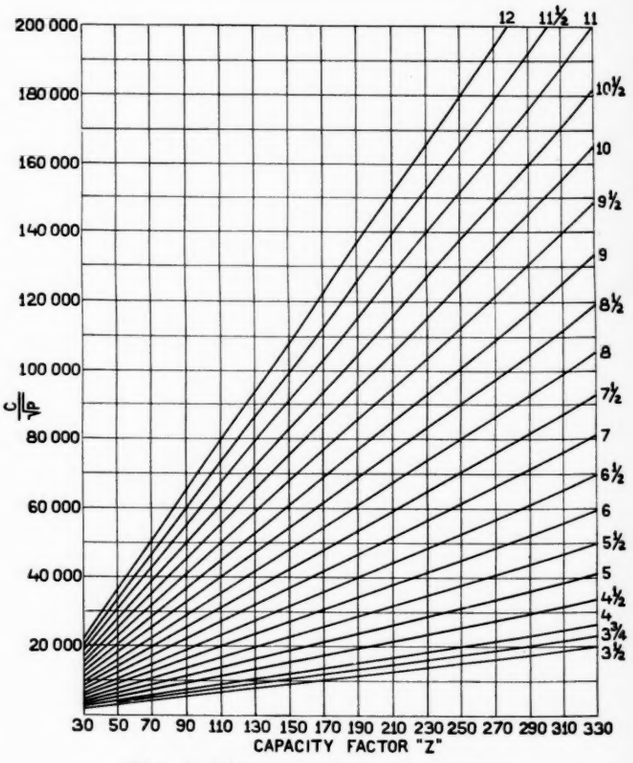


Fig. 3. Standard diameter diagram.

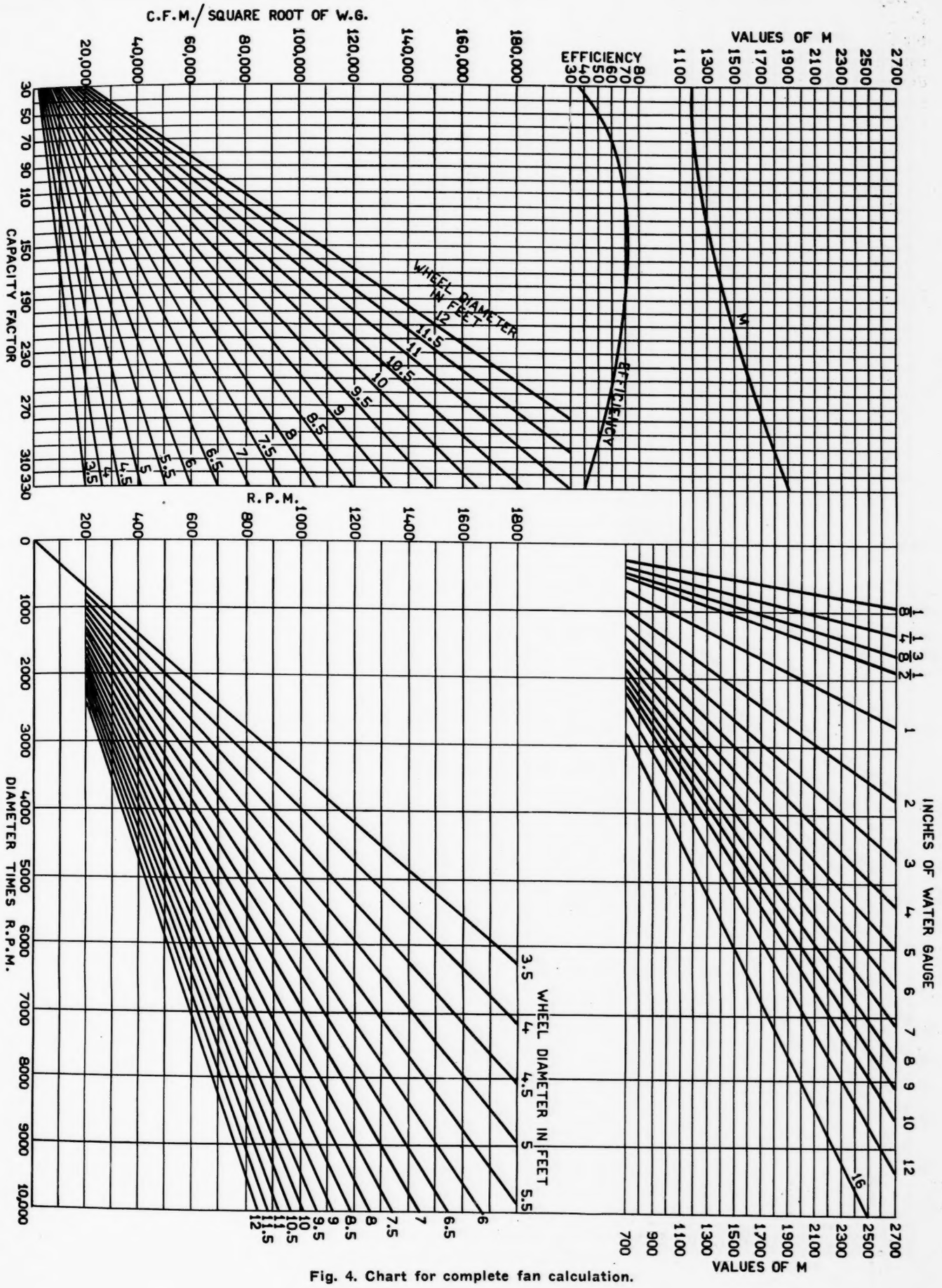


Fig. 4. Chart for complete fan calculation.

Beyond the mere convenience of the graphical solution, there are many desirable features. They are: Better fan specifications by the purchaser; more definite comparisons between competitive fans of the same fundamental type; gradual elimination of exaggerated claims for performance because centrifugal machines naturally perform as to type; development of better fans; development of more types of fans thereby giving fan users a broader field from which to select; better direction of research work relating to fans; a clearer picture of the fundamentals of fan application; a frank recognition of specific speed such as has permitted the great improvement in design of hydraulic turbines and centrifugal pumps; a simple check of existing installations.

Thus, if it be known that a fan of definite proportions is required to deliver a fixed volume at some pressure, the capacity factor Z may be readily computed. From the manufacturer's capacity factor, the relative point of performance is located and it can be seen at a glance whether the fan is too large or too small for the job.

It also would show when standard fans should be replaced by special designs.

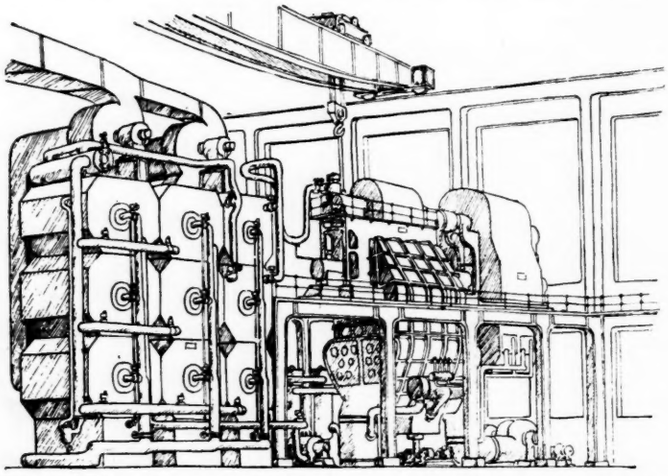
The laying out of special fans would become relatively simple. Conditions fix specific speed. Design fixes the corresponding ratio, X. The chosen revolutions per minute and required X fix the diameter. Specific speed fixes the efficiency for the design chosen. Therefore, a similar special fan may be readily computed. With a wide range of types and the determination of the effect of changing relative width, it is possible to choose the best combination of type and relative width.

The reader will no doubt visualize many further steps that may be taken to bring the centrifugal fan into place where it will be better understood and more scientifically designed to meet required conditions.

Cellular Boilers Predicted for Future

WE may postulate that the boilers of the future will be gas fired. This means that there need be no coal, no storage provisions, no coal-handling appliances. Ash will not be present and therefore dust catchers and the troubles incident to boiler cleaning may be forgotten. The fuel will be brought into the station through a pipe, and the products of combustion, largely carbonic acid and nitrogen, will go out of the chimney in a clean state. The atmosphere will not be polluted with dust, and the coal pile on a windy day will not scatter coal dust over the neighborhood. The householder will light his heating boiler in the fall, and, regulating it with a thermostat, he should not have occasion to be aware of its existence till he shuts it off the following spring.

Having indicated the solution of the fuel problem, we must turn our attention to the apparatus, which is the boiler, since our subject is the boiler room of the future. We have today discarded the old forms of shell and fire-tube boilers and are coming more and more to a boiler which is a simple collection of tubes connected by headers of the same shape and of but little larger size. The laws of heat transfer are now fairly well known, and the advantages of a very rapid circulation on both the gas and water sides are thoroughly appreciated. We have at least six designs of boilers with exceedingly good characteristics which contain no large parts and which are truly safety boilers since a serious explosion of any of them is unthinkable. On many of these boilers the only sign that a break has taken place is the falling of steam pressure, which warns the operator that something has happened.



The boiler room of the future may be along these lines.

The boiler of the future will be built along these lines. There will be no storage of steam in large shells, in fact we shall go back 100 years to the schemes of a Yankee inventor, Jacob Perkins, who believed in and patented the idea that steam should be made when it was wanted, and used immediately, thus making possible the use of any pressure within the thermodynamic range. Such boilers will naturally be very much smaller in size than many of the present-day boilers. With gaseous fuel and the preheating of combustion air, the flame can be made exceedingly short and the heat liberation may be quite large. The combustion space, which today is of considerable size, will be much reduced, and the speed of the products of combustion through the boiler will be very high in order that the heat transfer may also be high.

I am inclined to believe that the boiler of the future might be termed a cellular boiler, in that it will be built up of a number of unit cells, each cell using a certain amount of fuel and generating a certain amount of steam, the number of cells in the boiler depending on the demand for steam. A boiler of this type would be self-contained with its auxiliaries, would make no dust or dirt, could be located in the same room as the turbine and generator, and the boiler room, as a boiler room, would disappear.—*George A. Orrok, in A.S.M.E. paper "The Boiler Room of the Future.*

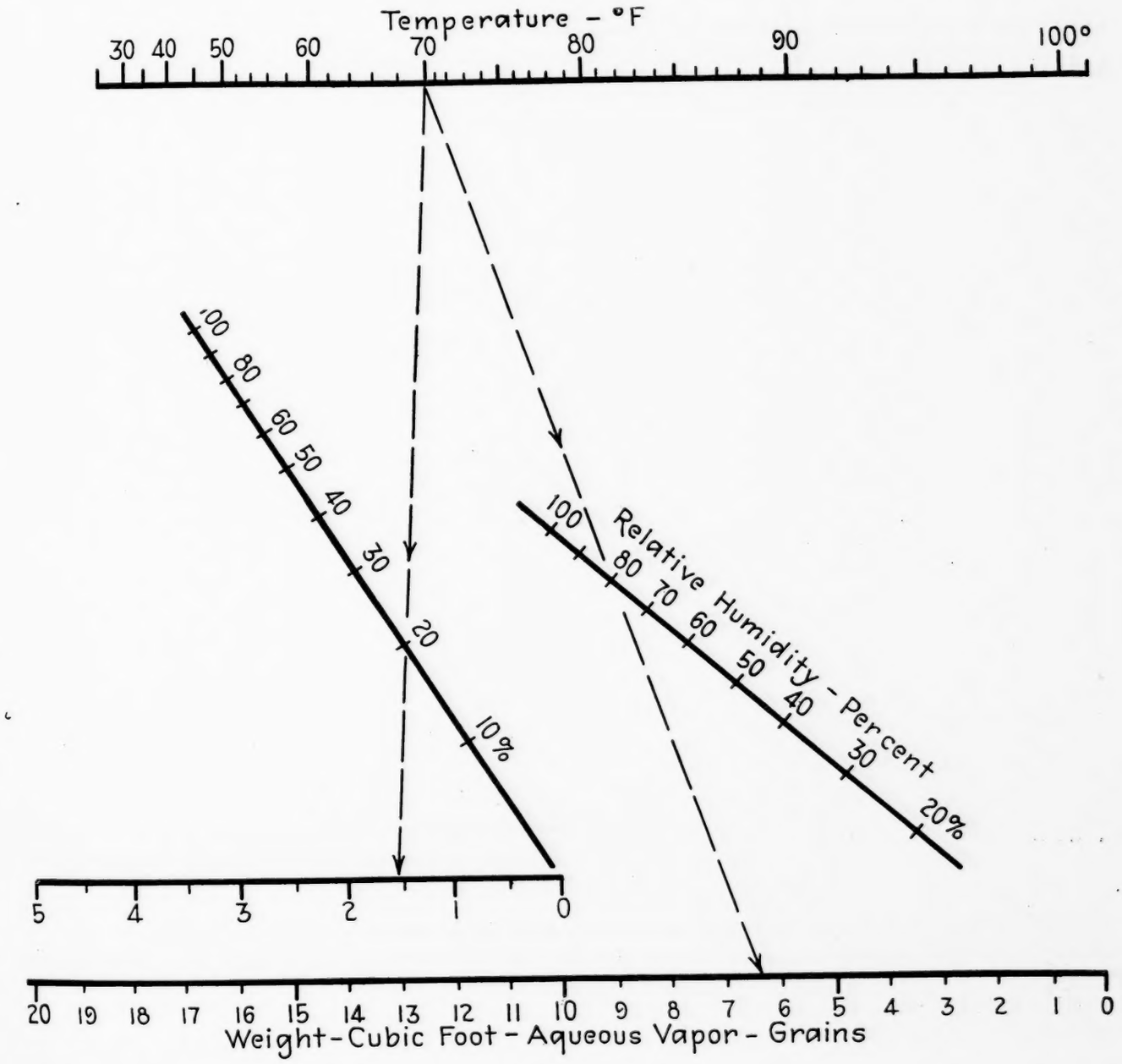
Chart for Quick Calculation of Moisture in Air

By FREDERICK S. DELLENBAUGH, JR.†

THE calculation of the weight of moisture in a given mixture of dry air involves several readings on the usual psychrometric chart and in addition several calculations. The accompanying chart reads directly the weight of the moisture in grains per cubic foot for a given dry bulb temperature and relative humidity.

The diagonal scales in the center of the chart are both relative humidity scales. The lower scale to the left is to be used with the long diagonal scale, and the long lower scale with the short diagonal line. To use the chart, connect the point representing the temperature on the upper scale with the point indicating relative humidity on either of the diagonal scales (using the one which is more suitable) and the extension of the line connecting the two points will read the moisture weight on the lower scale.

†Consulting Engineer, Chestnut Hill, Mass.



Mechanical Cooling Feature Of First Air

KEEN competition between the railroads and bus lines has resulted in noteworthy improvements in service on the part of the country's steam lines, both from the standpoint of the passenger and the shipper. The Baltimore & Ohio Railroad has been prominent among the carriers in its efforts to please its patrons, and among its accomplishments along these lines are the company's popular-priced dining car meals and the bus service between the Jersey City terminal and the various stations located in Manhattan.

One of the more recent attempts on the part of the railroads more adequately to serve their patrons has been along the lines of developing equipment for the air conditioning of passenger cars, particular attention being paid to sleeping cars and diners. Experimental work has been carried on by several roads, but the Baltimore & Ohio was the first to place in service a complete air conditioned train. This train, *The Columbian*, made its initial run with air conditioned cars on May 24, running between New York, Baltimore and Washington. The achievement is the result of the combined efforts of the mechanical and electrical engineers of the Baltimore & Ohio and air conditioning engineers of the York Ice Machinery Corporation.

Editor's Note—While this issue was going to press word was received from the Baltimore and Ohio Railroad that a second air conditioned train had been placed in service from New York to Washington and return on July 20.

Some years ago an attempt was made to cool the air in passenger cars with ice. Air from the interior of the car was drawn over ice and then forced back into the passenger space. This slightly cooled the air and permitted windows to be closed, but the load variations of melting ice presented a difficult problem. The servicing of cars was costly and the space required for ice bunkers was considerable. These factors were both serious disadvantages. Moreover, the weight of the ice carrier was excessive, especially for long runs with no scheduled stops. Experiments indicated that to produce adequate results, this type of cooling system demanded a melting rate of 8,000 to 10,000 lb. of ice per day per coach.

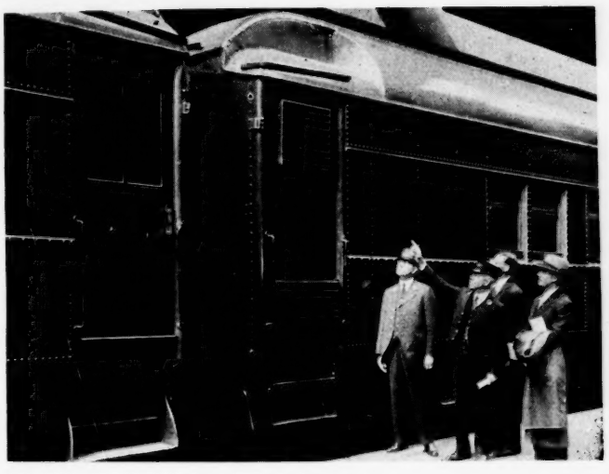
The next step in the evolution of the air conditioned train was to consider mechanical refrigeration for continuous and uniform production of temperatures low

Sunroom parlor observation car on The Columbian.

The "Atlantic," the locomotive shown below, pulled the first Baltimore and Ohio train into Washington when the extension to that city was completed.

Conditioned Train

The Columbian, first all-air-conditioned train, in the Union Station at Washington.



The cooling tower is located inside the vestibule of one end of the car.

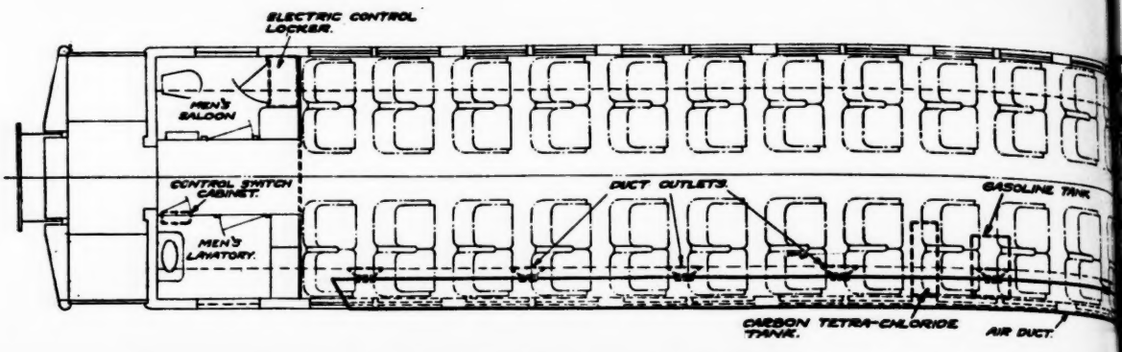
enough to absorb not only the heat developed in crowded coaches, but also that coming from outside the cars. Search was begun for a method of supplying power which would meet the exacting requirements of such an installation.

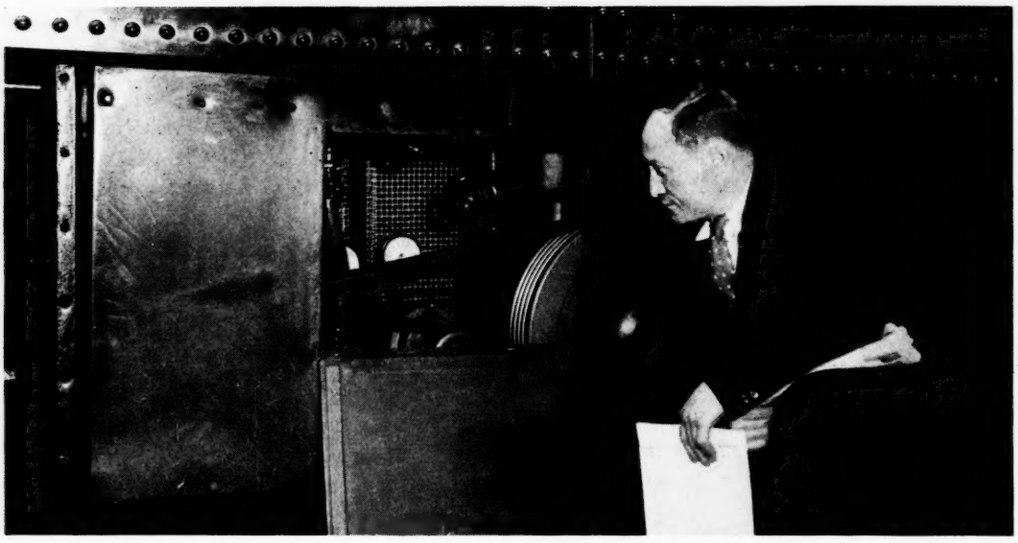
The use of an axle-driven generator was first tried, since coaches were already equipped with axle generators which supplied the current for lights, fans and, in dining cars, electric cooking equipment. More powerful generators were installed experimentally to supply the additional current needed to operate a cooling system. However, since power was not available when the train was standing in terminals and stations, the temperature in the closed cars quickly rose during the period when they were motionless and the air conditioning equipment consequently inoperative. During such periods of shut down, discomfort was quickly experienced by passengers, because of the sudden change from the lower temperatures provided when the train was in motion.

Later, storage batteries were installed in order to keep the cooling system in operation during the periods when the axle generator was ineffective. After trial this method was not considered entirely practical because of weight and space considerations.

These first applications of air conditioning by the Baltimore and Ohio were confined to dining cars, where cinders, soot, dust and high temperatures were most noticeably unpleasant. While this was a step forward in the effort to increase comfort of passengers, it was found that the passengers were reluctant to leave the dining car to return to hot and humid passenger cars. Dining periods were, therefore, unduly prolonged and accommodations for guests were accordingly materially reduced. It was finally concluded that the air conditioning of the whole train seemed to be the proper solution.

It was recognized that an independent, reliable source of power for supplying the current for mechanical refrigerating equipment should be available for each car so that any car might be taken from the train. A further point was that the conditioning system should operate independently of the speed of the train, so that it





The compressor and condenser water pump are motor-driven and are located in this box underneath the car.

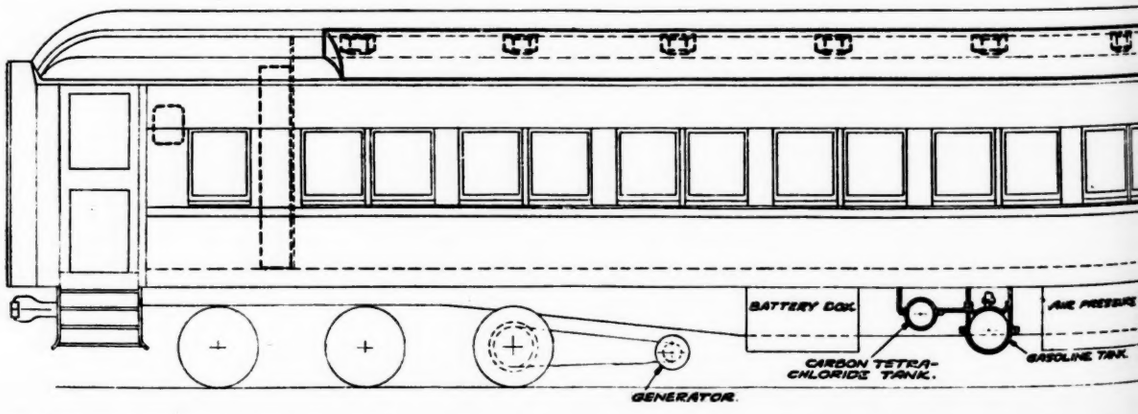
could be depended upon to pre-cool the train properly and to maintain the cooling while standing in stations and terminals.

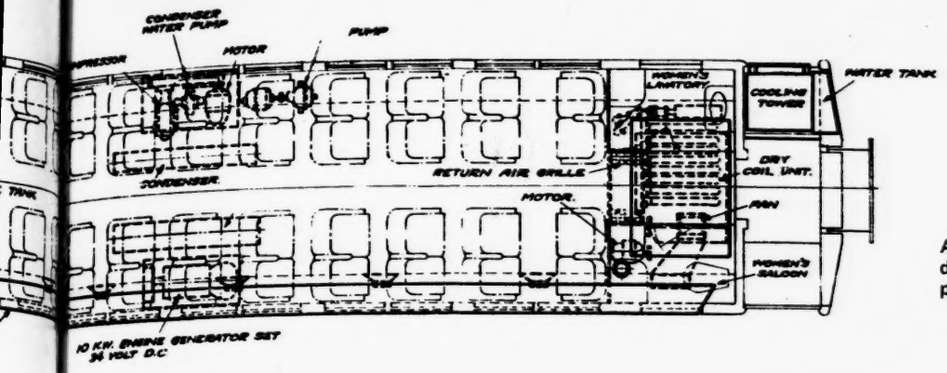
These considerations led to the use of an internal combustion engine, mounted on each car, as a source of power for driving a refrigeration compressor and cooling-water pump. The type of engine selected is similar to that used on some Zeppelins to provide electric power, and is light in weight and quiet and reliable in operation. The engine drives a generator and develops a capacity of 10 kw. Arrangements were also made whereby the air circulating fan is independent of the engine so that it can be operated on cool days when refrigeration is not required. On account of these requirements and space limitations, specially designed equipment was necessary.

The essential parts of the refrigerating system are the compressor, the condenser for liquifying the refrigerant, a cooling tower to provide a constant supply of cold water for the condensers, and a unit for cooling brine which in turn is passed through a cooling coil located in the air duct for cooling the air.

An unusual design of compressor was developed to meet the space requirements. It is installed with a steel base underneath the car. A V-belt drive is employed as this form of drive has the required dependability, efficiency and flexibility necessary for this type of service. The compressor base is of welded steel and also accommodates the cooling tower circulating pump, safety devices and gauges. The compressor unit is in a steel box not unlike the usual battery box, though smaller in size.

To provide the greatest factor of safety the refrigerant condenser was developed along the lines of condensers used for high pressure gases. It also is of special design to meet space limitations. No separately-built refrigerant receiver is employed. This is made possible by the principles of a newly developed condenser, drained continually through a float mechanism.





A plan view of one of the air-conditioned cars. At the bottom of these pages are shown the elevation and sections of the car.

The condensed refrigerant is continuously removed from the condenser and discharged into a shell and tube brine cooling unit which is located under the car near the compressor.

The cooling tower is of the forced draft type without nozzles. Its water distributing system is especially designed for railroad use. Condenser cooling water is circulated through the condenser and cooling tower by a pump mounted on the compressor base.

In the upper portion of the car the air conditioning unit is installed above the vestibule. Here the air is cleaned, cooled and dehumidified to produce the desired temperature and moisture content. The air is then delivered through a system of duct work to grilles in the upper portion of the car. It was necessary to eliminate draft entirely and yet to deliver a constant supply of air. This cooled air being heavier than the air in the car gradually descends and diffuses through the car. The air volume handled is at the rate of 30 complete changes per hour. Thermostatic control of the air is provided.

An electrically-driven brine pump under the coach pumps the brine through the cooler and through the cooling coils in the air conditioning unit. The power requirement of the entire refrigerating and air conditioning equipment is approximately 6 hp.

Probably no recent improvement in railroad equipment holds more promise of contributing to the comfort of travel than does the air conditioning of trains. Compact and lightweight apparatus has made this innovation possible, and the result has been attained at such a low cost per passenger that there is every reason to believe that air conditioning is destined to become an important part of railroad service, at least on the main lines of the larger roads.

The Baltimore and Ohio Railroad, which was organized 104 years ago, has a reputation as a pioneer in engineering. The company has never been backward in releasing information gained from its experience for the benefit of other engineers. An editorial in the "American Railroad Journal" in 1835 nominated the Baltimore and Ohio as the Railroad University of the United States, and commended the annual reports of the road in which the company made public a record of its experiences. Some of the Baltimore and Ohio's notable feats in engineering follow:

1828—Selected 4 ft. 8½ in. as the standard gauge for track, although other railroads were using gauges as wide as 6 ft. The gauge which the Baltimore and Ohio selected is today the standard for all railroads in this country.

1830—Peter Cooper completed the "Tom Thumb," one of the earliest and most successful locomotives built.

1834—Built a 700 ft. stone bridge over the Patapsco, designed for six-ton locomotives with their small trains, and is today in use carrying 300-ton locomotives with steel trains.

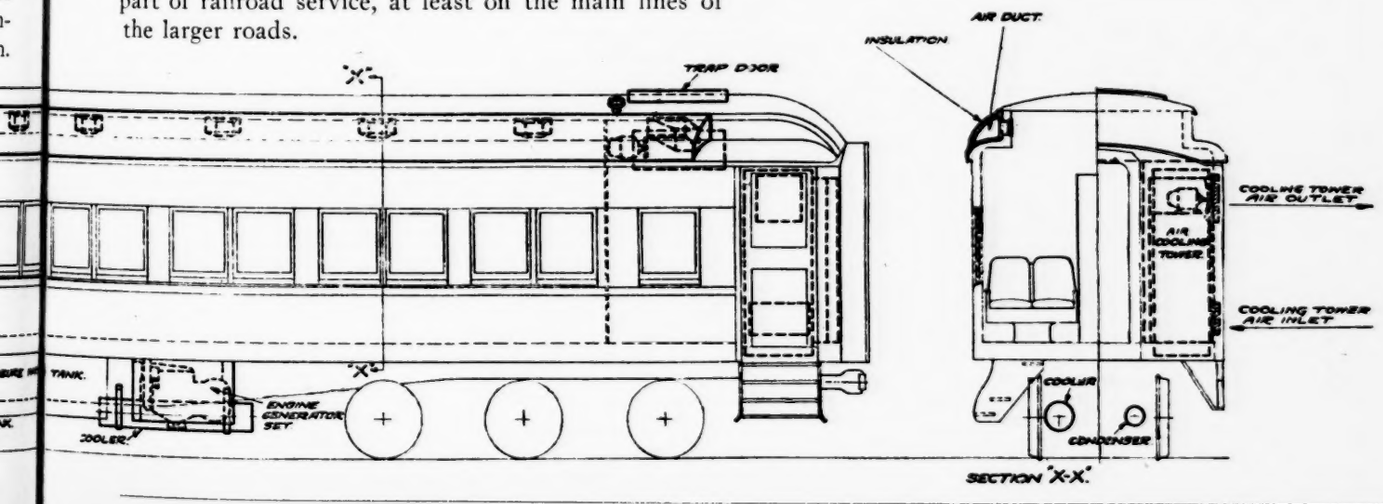
1843—Cooperated with Prof. S. F. B. Morse in placing along its road bed his first telegraph wires over which the first telegram was transmitted.

1852—Built a 124 ft. single suspension wrought-iron truss bridge at Harpers Ferry, which stood until 1924.

1895—Placed in service the first electric locomotive used on any steam railroad in the United States, hauling trains through the Howard Street Tunnel in Baltimore.

1904—Introduced the first articulated Mallet compound locomotive ever built and operated in the United States. Today there are over 2000 engines of this type in use.

1931—Built and began operation of *The Columbian*, the first all-air-conditioned train in the world.



Sound—I

By R. V. PARSONS[1]
and
JOHN S. PARKINSON[2]

Acoustically treated walls and ceiling minimize unnecessary sounds at the broadcasting studio of WFAA, Dallas, Texas.

To most of us sound is known almost entirely by the sensation it produces, much as is the case with heat. However, both sound and heat are forms of energy, and obey well-known physical laws. Nearly everyone knows that sound can be generated by a vibrating body, usually a column of air or a diaphragm, but few have any clear conception of what happens between the time the sound leaves the source and the moment the ear detects its presence. This general lack of understanding is often rsponsible for serious blunders.

Sound is always generated by some vibrating object. The casing of a fan or a motor is capable of setting up sound waves, or in other instances a train of waves may be started by a sudden sharp disturbance of the air itself, as in the case of a passing bullet or the impact of fan blades. It must be remembered, however, that the ear ordinarily cannot detect sound unless it is present in the form of waves in the air. This, of course, does not include cases where the ear is laid directly against the vibrating surface.

In many cases where it is not practicable to stop the vibration itself, it is possible to prevent it from getting into the air. The classic instance, of course, is the vibrating violin or piano string, which makes almost no sound until it is attached to a sounding board which affords the proper coupling to the air. Sound energy is transmitted in air by the vibrating molecules, and unless sufficient surface is in contact with the air to set an appreciable number of these molecules into vibration, there is not enough sound energy to affect the ear.

It must not be supposed, however, that air is the only medium which will transmit sound readily. Solids—such as iron, steel, wood, etc.—and liquids—such as water—will usually transmit sound energy more rapidly and with considerably less loss through dissipation. A vibration communicated to the metal shell of a ventilating duct will travel throughout its entire length, and a listener with a stethoscope may find very pronounced vibrations a hundred feet from the source. Some of our most baffling problems arise from this fact, for now and again the sound will travel as far as this or even farther before finding a suitable surface by way of which to escape into the air, with the result that the listener in the room may find it almost impossible to hunt down the original source. It may be, and often is, several rooms or floors away.

There are various possible ways of preventing this sound transmission either in air or in a solid material. Sound traveling in any medium seems to have a preference for remaining in that same medium, and if a new substance is encountered, much of the energy will be reflected and will not enter the new medium. Sound waves in air are to a very large degree reflected when they encounter a hard, rigid wall. Similarly, a train of waves traveling along a metal duct lining will lose a large portion of its energy if it is compelled to pass through a flexible rubber or canvas jacket in order to continue its journey. This principle has been used with notable success in many problems of machinery isolation. A series of layers of different materials, such as felt, rubber and lead, will reflect a very large percentage of the sound which attempts to pass through. The more markedly the adjoining mediums differ in density and elasticity, the more will incident waves tend to be reflected, and the more efficient will the construction be in preventing sound transmission. Thus, for example, when sound waves in air strike a concrete wall, more than 98% of the energy will be reflected, and even a fraction of that not reflected will be absorbed by frictional dissipation in the surface of the material.

Mention was made earlier of the various characteris-

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[2] Staff acoustical engineer, Johns-Manville, New York.

Identifying Characteristics

Heating and ventilating engineers have long been somewhat interested in sound, especially where problems of water hammer and vibration in ducts have been encountered. However, such interest has been entirely secondary, while today with the demands for extreme quiet in buildings, such as talking picture theaters, the problem becomes one of primary importance.

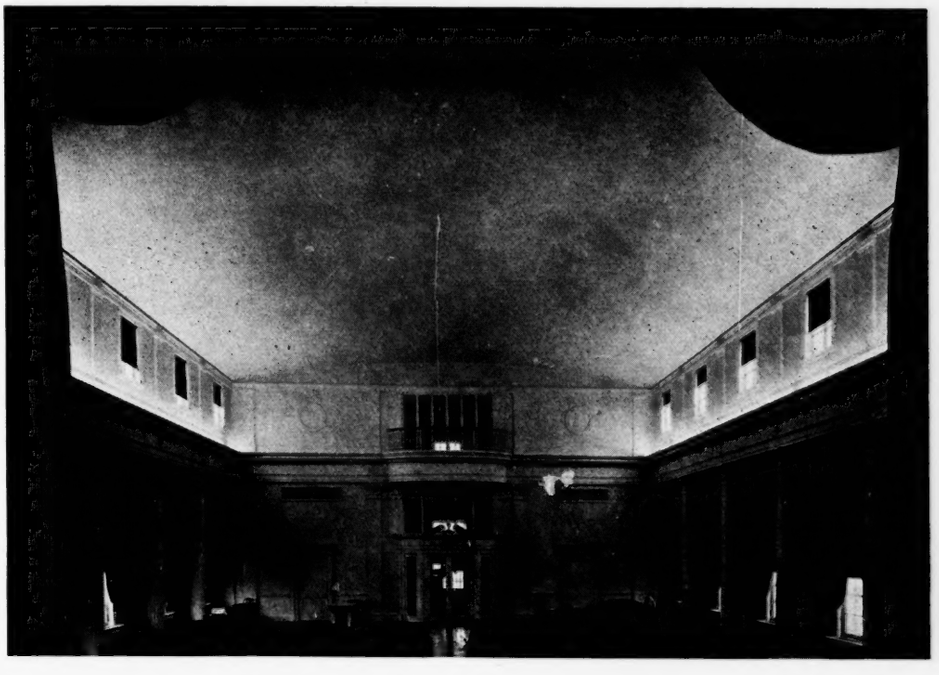
In this article the authors discuss sound in a general way, referring to its characteristics, method of generation and transmission.

tics of sound which enable the listener to describe and identify it. One of the most important of these is pitch. For purposes of a general discussion it will be sufficient to say that what the ear recognizes as a change in pitch is the varying sensation produced by changes in the frequency of the sound, i.e., in the number of vibrations per second. It is the quality of being high or low, acute or grave. In terms of frequency, a low pitch would be somewhere in the neighborhood of 100 to 200 cycles per sec., or about the fundamental frequency of a man's voice. A high pitch, the upper range of a soprano's voice, would be about 1200 cycles. A very high pitched sound, such as the hum of a mosquito, might run as high as 10,000 or 12,000 cycles. The frequency range which the ear can detect varies with the ordinary person from about 20 cycles per sc. to about 16,000 cycles.

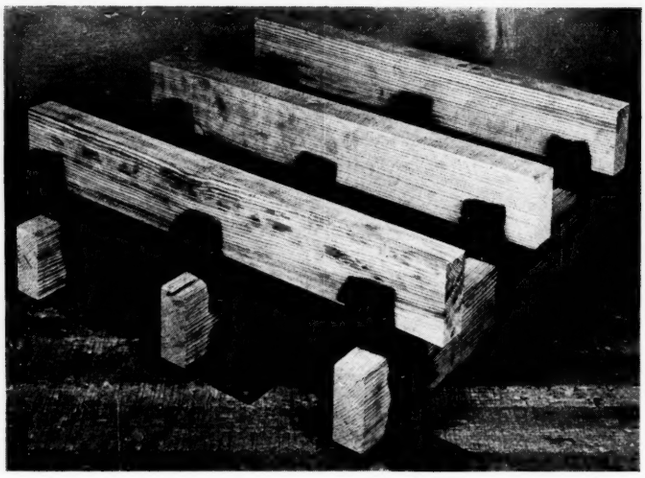
In general the higher pitched sounds are more unpleasant. We apply terms like harsh and shrill to these frequencies, whereas sounds in the lower end of the range we call mellow, rich, full, etc. Certain very low pitched sounds are likewise annoying, particularly if they are loud, but this is more due to the physical vibrations set up. Probably the least objectionable range of frequencies is from about 100 cycles to 500 cycles, although this of course is purely a matter of individual judgment. These observations are based on experience with machinery quieting, automobile mufflers, fans, and other such devices.

Nearly all sounds contain a number of different frequencies. The number of these frequency components and their numerical relation to one another determine what is known as quality. In a musical sound the various components usually have a definite numerical relation to the fundamental, being twice as great, three times as great, six times, and so on, as the case may be. In the type of sound which we call noise there are always a large number of these components, but they usually have no set relation to one another, and as a result are displeasing to the ear. Often, where it is not possible to eliminate all the energy in a sound it may be possible to remove certain of the more displeasing frequencies, so that while it may still be audible, it will no longer be so unpleasant. Sudden impulses, such as shocks, blows, explosions, nearly always create what we call noise because they are of such short duration that the ear has no opportunity to appreciate the frequency relationships. Similarly odd shaped or broken surfaces nearly always create noise when set into vibration because their complex structure prevents them from vibrating in any simple manner.

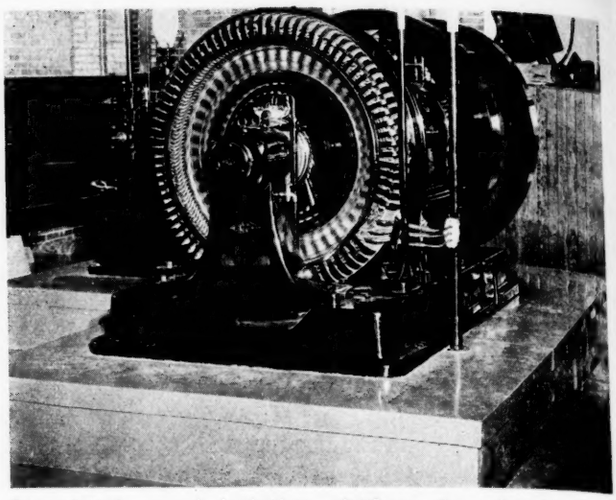
Up to this point no detailed mention has been made of loudness. However in a discussion such as this it is important to know something of what determines the loudness of sounds since this characteristic more than any other one determines the annoyance or disturbance factor. The ear is an exceedingly sensitive



The acoustically treated auditorium of the Women of the World War Building, Washington, D. C.



Sound isolation platform showing felt-lined chair.



Completed sound isolation platform for absorbing machinery vibrations.

organ, and responds to very small stimuli in the form of sound waves. The least audible sound power is something of the order of 0.0000000001 microwatts, or 0.0000000000000001 watts. Even very loud sounds, such as those produced by a bass drum or an organ, will seldom have much more than a watt of power. It becomes apparent immediately why such extraordinary precautions are necessary to eliminate various sounds, since the ear is so extremely sensitive in detecting them.

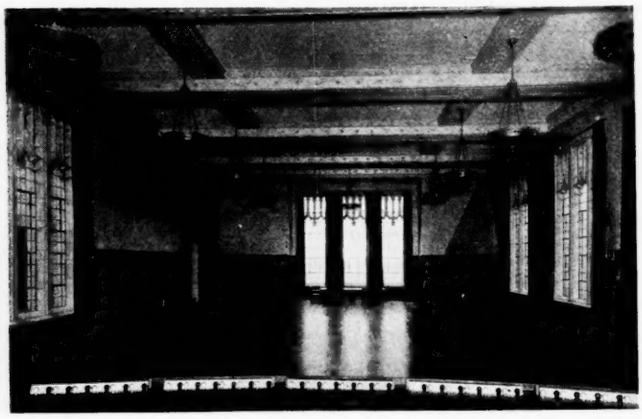
Loudness Is Not Proportional to Energy in Sound Wave.

The sensation of loudness is not directly proportional to the amount of energy contained in the sound wave. The ear recognizes *changes* in loudness in a fashion which is approximately logarithmic, i.e., the amount of change must be a certain fixed minimum percentage of the original quantity of sound present in order for the ear to recognize the fact that a change in loudness has occurred. This fact has been made the basis for a system of loudness units known as decibels,[1] which are measured in terms of the logarithm of the physical energy.

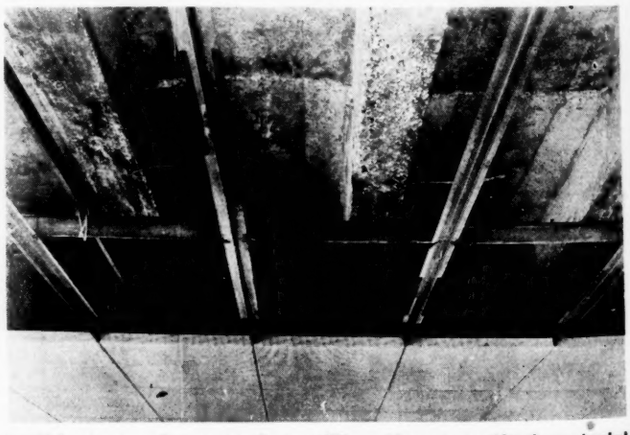
Less is known about relative loudnesses of different sounds. They are apparently not directly proportional either to the energy ratios, or to the loudnesses expressed in decibels, being less than the first and greater than the second. Without going into an extended discussion, perhaps the most convenient way of working with relative loudness is to think of them as being roughly proportional to the square root of the energy. For example, if a certain fan unit were generating 100 microwatts of sound, and quieting methods were employed which reduced the amount of sound emitted to 1 microwatt, the reduction in apparent loudness would be of the order of 90%. Instruments are available with which to make these measurements, both with and without an accompanying frequency analysis, and they will be discussed more in detail later.

One more fact is worth noting in connection with this matter of the loudness of sounds. Whether a sound will or will not be audible depends not only on the loudness of the sound itself, but likewise on the amount of masking sound already present. Thus, a machine unit which would be perfectly satisfactory in an office building would be rather disturbing in a theater, and quite out of the question in a radio studio. This is because even a quiet office will have a noise level of 50 decibels above the threshold, whereas many theaters have no more than 25, and a radio studio may not have more than 10. The level of extraneous sound, such as that produced by ventilating equipment should be at least 15, and preferably 25 decibels below the sound level already present in the room.

[1] The decibel is a standard unit used in sound measurement. On this scale the least audible sound has a value of one. An average office has a level of fifty to sixty decibels, and an airplane motor will run more than one hundred decibels. The decibel is the least change in loudness that the ear can detect.



Auditorium of a midwestern public utility building. The walls and ceiling are treated to absorb sound.



In this type of suspended ceiling the acoustical material takes the place of metal lath and plaster.

A Review of Psychrometric Charts

Part III

By C. O. MACKEY

The Ware Chart

All of the psychrometric charts, heretofore discussed, have been drawn for a single barometric pressure of 29.92 in. of mercury. It is intended, of course, that these charts are to be used for any ordinary barometric pressure, for the error accompanying such use will usually be small. However, Charles M. Ware has prepared a psychrometric chart, on which the barometric pressure is treated as a variable. The mol is used as a unit on his chart, and before the chart is explained, there are a few facts in connection with this unit to be recalled.

A pound mol, or as abbreviated in the chart, one mol is the number of pounds of a substance represented by the relative weight of the combining unit. For example, one mol of O_2 is 32 lb., one mol of N_2 is 28 lb., and one mol of H_2O is 18 lb. Equal volumes of all gases, under similar conditions of pressure and temperature, contain the same number of molecules. Therefore, the *volume per cent* of any mixture of gases is also the *mol per cent*, and it might be added, also, is the same as the *partial pressure per cent*. For example, consider, a mixture of two gases, such as air, which is approximately 21% O_2 and 79% N_2 by volume. This means that 21% of the total number of molecules in the mixture are O_2, and 79% are N_2 molecules. It also means that the partial pressure of the O_2 is 21% of the total pressure exerted by the mixture. To find the molecular weight, or the number of pounds in one mol of a mixture, a summation is taken of the products of the volume fraction by the molecular weight of each constituent. In this manner, it can be shown that the molecular weight of dry air of sea level composition, is very close to 29. Mr. Ware, in his chart, has used 28.85 as the molecular weight of dry air.

Considering, first, the primary coordinate scheme of the Ware chart, shown in Fig. 7, the per cent, by volume, of vapor in the mixture of dry air and vapor, has been plotted, as ordinate, vs. dry bulb temperature, as abscissa. The "saturation" curves, or the lines for a relative humidity of 100%, are located on this coordinate system for several different barometric or mixture pressures. These lines can be readily located, since the fraction by volume of vapor, V_v, in a mixture of dry air and vapor with relative humidity of 100%, is

$$V_v = \frac{p_d}{p_m}$$

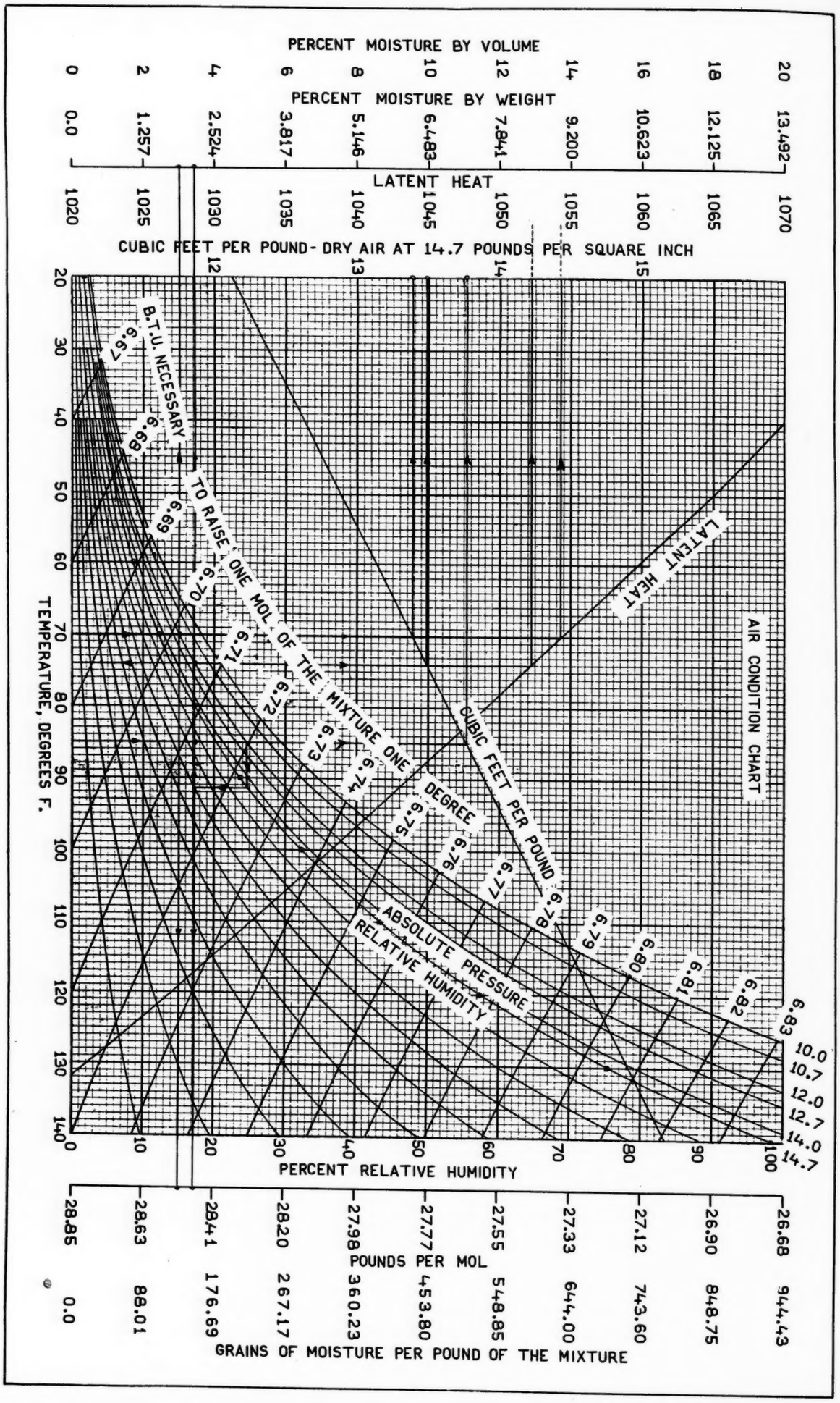
where p_d is the saturation pressure at the dry bulb temperature, and where p_m is the pressure of the mixture, or commonly, the barometric pressure. On the primary coordinate system, also, are located lines of constant relative humidity, *but for one barometric pressure only, viz., 14.7 lb. per sq. in. absolute.* These lines of constant relative humidity are very easily located, since at any given dry bulb temperature, the fraction by volume of vapor is directly proportional to the relative humidity. For example, with a barometric pressure of 14.7 lb. per sq. in. and a dry bulb temperature of 100°F., for 100% relative humidity, $V_v = 6.46\%$ while for 50% relative humidity, $V_v = 3.23\%$. At first glance, it might seem that these lines of constant relative humidity should be put on the primary coordinate system for the several different barometric pressures, but it is not necessary to do this. Instead, the chart is entered, as shown in Fig. 7 at the value of the given dry bulb temperature, followed vertically up to the "saturation" curve for the given barometric pressure, then horizontally to the "saturation" curve *for 14.7 lb. per sq. in. barometric pressure*, and then vertically to the given relative humidity. The ordinate at this point gives the per cent by volume of water vapor in the mixture of dry air and steam.

On the chart there are auxiliary scales for several secondary variables that depend only on the value of V_v, i.e., the fraction by volume of water vapor in the mixture. Such secondary variables are the fraction, by weight, of water vapor in the mixture; the molecular weight of the mixture, in pounds per mol; and the grains of water vapor in one pound of the mixture.

In addition to these auxiliary scales for secondary variables, there are lines of constant molal specific heat at constant pressure plotted on the primary coordinate system of fraction vapor by volume vs. dry bulb temperature. As sooon as V_v is found, as explained above, the intersection of the line of given dry bulb temperature with a horizontal line through this value of V_v gives the instantaneous molal specific heat of the mixture in the given state. To find the specific heat of the mixture on the pound basis, the molal specific heat is divided by the molecular weight of the mixture.

Also, there are auxiliary curves of specific volume of dry air at a pressure of 14.7 lb. per sq. in. absolute and of the latent heat of vaporization of water, plotted vs. temperature.

As an illustration of the use of the Ware chart, suppose that the quantity of heat that must be abstracted in order to cool 100 lb. of a mixture of air and water vapor from a temperature of 85°F. to a temperature of 70°F. is required. Assume that the initial relative humidity of the air is 70% and that the total pressure of the mixture of air and water vapor is 12 lb. per sq. in. absolute. Entering the chart at a dry bulb temperature of 85°F., move vertically to the "saturation" line for a pressure of 12 lb. per sq. in. absolute then hori-


PERCENT MOISTURE BY VOLUME
PERCENT MOISTURE BY WEIGHT
LATENT HEAT
CUBIC FEET PER POUND - DRY AIR AT 14.7 POUNDS PER SQUARE INCH
B.T.U. NECESSARY TO RAISE ONE MOL OF THE MIXTURE ONE DEGREE
LATENT HEAT
AIR CONDITION CHART
CUBIC FEET PER POUND
ABSOLUTE PRESSURE
RELATIVE HUMIDITY
TEMPERATURE, DEGREES F.
PERCENT RELATIVE HUMIDITY
POUNDS PER MOL
GRAINS OF MOISTURE PER POUND OF THE MIXTURE

Copyright, 1928, by Charles M. Ware.

Fig. 7. The Ware Psychrometric Chart.

zontally to the saturation line for 14.7 lb. per sq. in. absolute, then vertically down to the line of constant relative humidity of 70%. At this point, read the fraction by volume of water vapor in the mixture to be 3.45%, the fraction by weight to be 2.18% and the pounds per mol to be 28.47. To find the instantaneous molal specific heat in the initial state, this line of constant vapor volume is traced horizontally to its intersection with a temperature of 85°F., and the specific heat is read as 6.711 B.t.u. per mol. per deg. F., or

$$\frac{6.711}{28.47} = 0.236 \text{ B.t.u. per lb. per deg. F.}$$

Now the line of constant vapor volume intersects the "saturation" curve for a pressure of 12 lb. per sq. in. absolute at a temperature of 74°F. At this state the relative humidity is 100%, the fraction by volume and by weight of water vapor in the mixture and the molecular weight of the mixture are the same as in the initial state and the specific heat is

$$\frac{6.705}{28.47} = 0.236 \text{ B.t.u. per lb.}$$

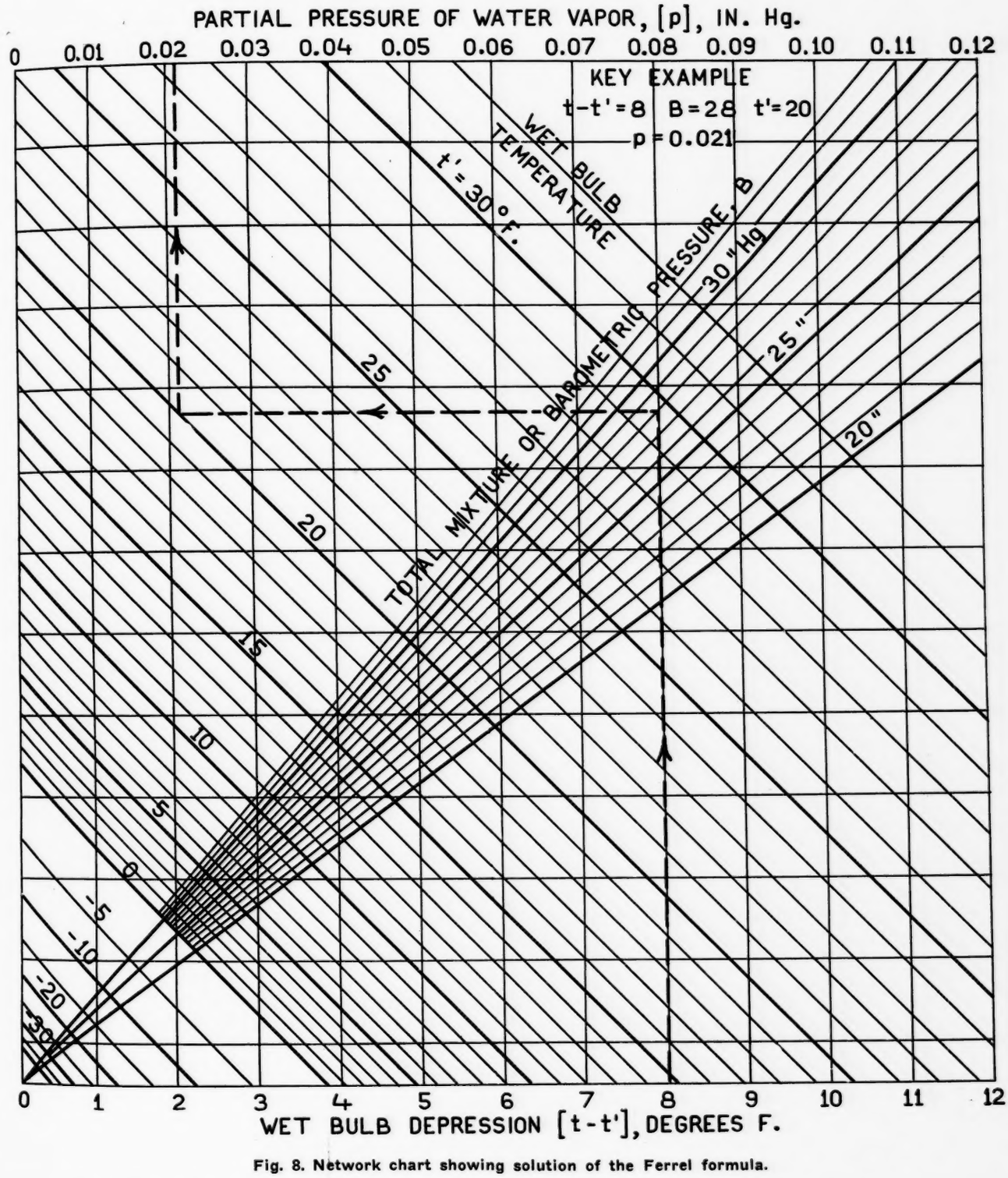


Fig. 8. Network chart showing solution of the Ferrel formula.

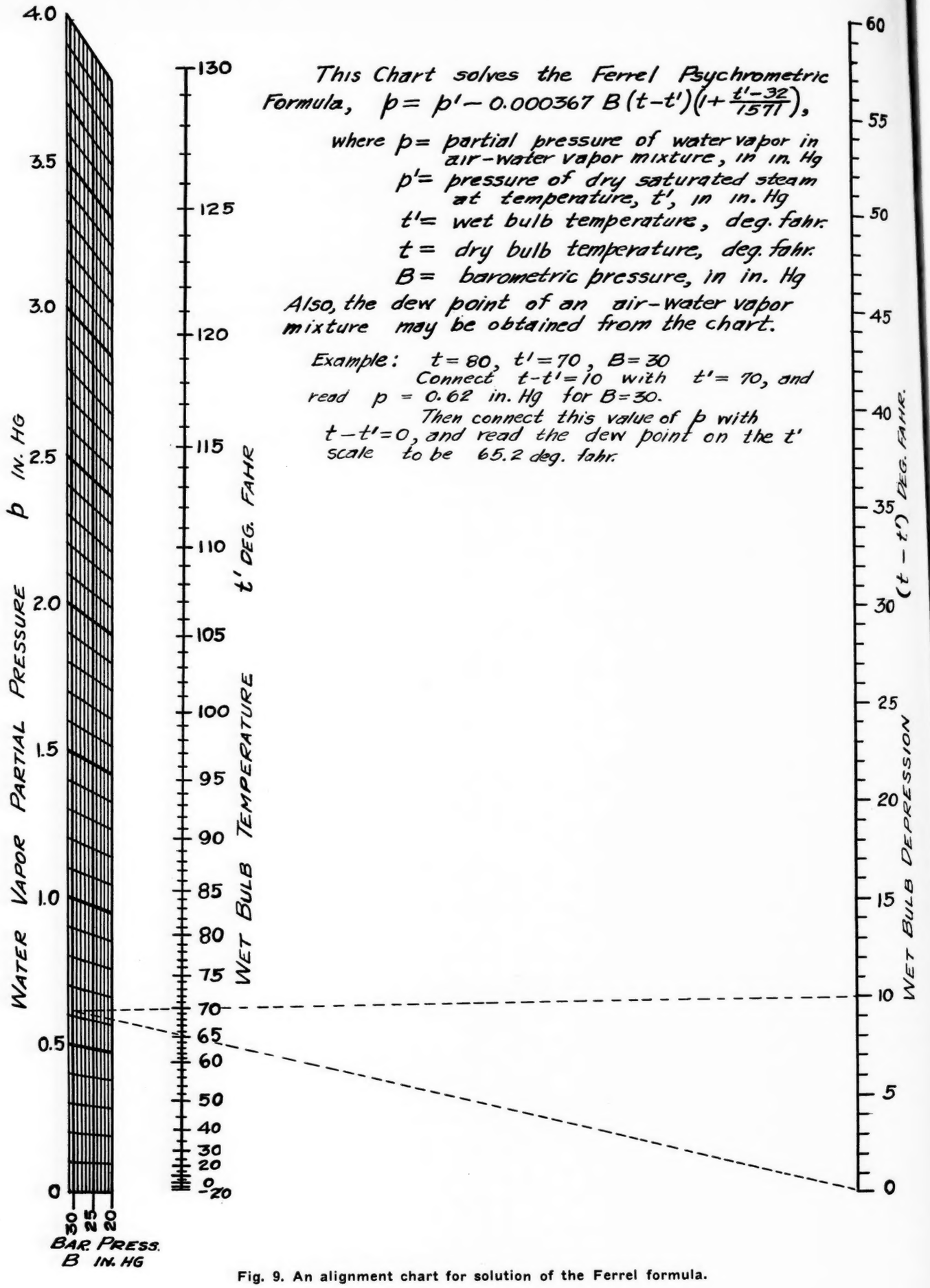


Fig. 9. An alignment chart for solution of the Ferrel formula.

per deg. F., closely. Continuing the cooling of the air, the final state is located on the "saturation" curve for a pressure of 12 lb. per sq. in. absolute at a temperature of 70°F. In this state, the fraction by weight of water vapor in the mixture is 1.9%, the molecular weight of the mixture is 28.52, and the specific heat is

$$\frac{6.701}{28.52} = 0.235 \text{ B.t.u. per lb. per deg. F.}$$

Evidently, 2.18 — 1.9 or 0.28% of the water vapor in the mixture, or 0.28 lb. of water are condensed between temperatures of 74° and 70°.

To cool the mixture from 85° to 74° requires the removal of $100 \times 0.236 \times 11 = 260$ B.t.u. To cool the air from 74° to 70° requires the removal of approximately $\left(\frac{99.72 + 100}{2}\right) \times 0.2355 \times 4$ or 94 B.t.u. To condense and cool the water requires the removal of approximately $(0.28 \times 1053 + 0.28 \times 2)$ or 296 B.t.u. The total quantity of heat removed is then 650 B.t.u.

If the reader has followed through the necessary lines on the Ware chart to solve this problem, he may well conclude that the chart is very complicated. Although the chart includes the atmospheric or mixture pressure as a variable, it sacrifices wet bulb temperature. To use the Ware chart, the value of the relative humidity must first be determined, and this must be found on another chart or by means of suitable equations involving dry bulb and wet bulb temperatures and barometric pressure.

The Mollier I-X Diagram

The Mollier steam, water, or ice and air mixture chart, which was thoroughly described in this publication recently[10] by Arnold Weisselberg is a novel form of psychrometric chart.

In this chart, for the steam or water and air mixtures, heat content is plotted against absolute humidity, and on this coordinate system are drawn lines of constant temperature and constant specific weight or density. Marginal scales are included on the chart to give the inclination for the mist isothermals, and in some charts, the ice isothermals.

The chart adds little to existing psychrometric charts when the state points fall in the region where the mixture is composed of steam and air, the only field covered in the ordinary psychrometric chart. The region of fog, however, is shown in the Mollier diagram, and processes which carry the state point into this region may be graphically represented. Mr. Weisselberg has described how the chart may be used advantageously in this connection.

If any considerable use of the Mollier chart is contemplated, one possible change in the chart shown by Mr. Weisselberg might be made in order to add to its utility. In the Weisselberg chart, lines of constant humidity are shown for but one barometric pressure, viz., 29.92 in. of mercury. In accordance with equation (6a), however, absolute humidity,

$$\text{A.H.} = 0.622 \frac{(\text{R.H.})\, p_a}{B - (\text{R.H.})\, p_a}$$

where A.H. = absolute humidity.
R.H. = relative humidity, as a fraction.

[10] HEATING AND VENTILATING, January and February, 1931.

p_a = the pressure of dry saturated steam at the temperature, t_a.
B = the total pressure of the mixture, in the same units as p_a.

This equation can also be written as

$$\text{A.H.} = 0.622 \frac{\left(\frac{\text{R.H.}}{B}\right) p_a}{1 - \left(\frac{\text{R.H.}}{B}\right) p_a}$$

This illustrates the absolute humidity at any dry bulb temperature (the temperature fixing p_a), is the same for any constant ratio of R.H. to B, irrespective of the individual values of R.H. or B.

Therefore, by plotting on the Mollier chart, lines of constant values of $\frac{\text{R.H.}}{B}$, *instead of lines of constant R.H. at one single value of B,* the chart may be used for *any* pressure of the mixture, B. For example, if the relative humidity of the mixture is 40% when B is 20 in. of mercury, the state point of the mixture is located on the $\frac{\text{R.H.}}{B}$ line of 0.02 and at the proper dry bulb temperature.

Summary

Unquestionably, the use of psychrometric charts results in a considerable saving in time in solving problems. Any chart of the Grosvenor type such as the chart of Lavine and Sutherland is very useful in solving problems in drying. Charts, such as the Hill, Bulkeley, or Carrier charts, are of great utility in solving problems in air conditioning. The Mollier I-X diagram is useful when mixtures of water or ice and dry air, as well as of steam and dry air, are involved.

However, in teaching the thermodynamics of heating and ventilating, a thoughtful teacher will not allow students to use charts until they understand the fundamental thermodynamic principles upon which these charts are based. The practicing engineer, also, unless he wishes to become simply a handbook engineer, will not use charts until he is sure of the underlying principles. It is our opinion that the careless use of psychrometric charts has resulted in covering up many fundamental psychrometric principles. For the student who is interested in knowing the effect of *all* of the variables in psychrometric problems, the author here presents the necessary fundamental thermodynamic principles.

First, we need an equation to locate the state of steam in the air after the barometric pressure or mixture pressure, and the dry and wet bulb temperatures have been experimentally determined. The equation, if rational in form, must express, mathematically, the dynamic equilibrium between the rate of water evaporation and the rate of heat transfer to the water. It is because of this equilibrium that the wet bulb thermometer reads a steady temperature. The following general equation meets the rational requirement:

$$\frac{p' - p}{t - t'} = \frac{f}{k_a r'} \qquad (7)$$

where t = dry bulb temperature
t′ = wet bulb temperature
p = actual partial pressure of steam in mixture

p' = pressure of dry sat. steam at t'
f = film coefficient of heat transfer between air and water
k_d = coefficient of vapor diffusion
r' = latent heat of water at t'

The Ferrel psychrometric formula used by the U. S. Department of Agriculture is of such a form and this equation follows:

$$\frac{p' - p}{t - t'} = 0.000367\, B\left(1 + \frac{t' - 32}{1571}\right) \qquad (8)$$

With t and t' available from a sling psychrometric reading, and B, the barometric or mixture pressure determined, the equation may be solved for p. The pressure and the temperature of the steam in the steam-air mixture are then known, and the state of steam is fixed.

Second, an equation is necessary for the absolute humidity, A.H., of an air-steam mixture. This equation has been mentioned before, and assuming the steam in the mixture obeys the ideal gas laws, the equation for A.H. is

$$\text{A.H.} = 0.622\ \frac{p}{B - p} \qquad (9)$$

where A.H. = the pounds of steam mixed with each pound of dry air.
p = the actual partial pressure of the steam.
B = the total pressure of the mixture, in the same units as p.

Third, the general energy equation can be applied to processes such as the adiabatic saturation process, the heating or cooling of air-steam mixtures, etc. In the most general form, this equation may be explained, using Fig. 10, as follows.

The rectangle may represent any apparatus like a drier, humidifier, dehumidifier, cooling tower, or the like, by choice of the proper direction of the arrows. A mixture of air and steam, such as atmospheric air, enters in state 1 and leaves the apparatus in state 3. Water is supplied at some temperature, t_2. For the flow of one pound of dry air, with accompanying vapor, through the apparatus, if there is no appreciable change in the velocity or elevation of the fluids, and no mechanical energy delivered to or by the apparatus, then

$$h_{m1} + E_h + (\text{A.H.}_3 - \text{A.H.}_1)\, h_2 = h_{m3} + R_c$$

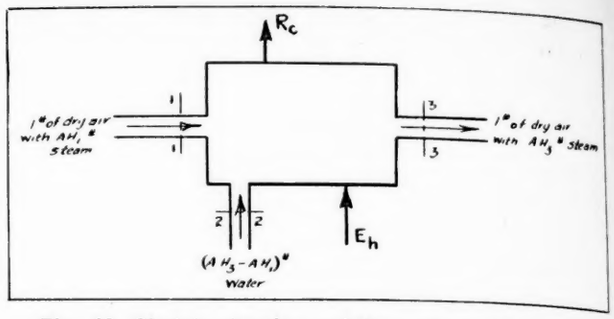


Fig. 10. Sketch showing solution of equation (10).

or

$$E_h = h_{m3} - h_{m1} + R_c - (\text{A.H.}_3 - \text{A.H.}_1)\, h_2 \qquad (10)$$

where E_h = the quantity of heat supplied per pound of dry air.
R_c = the quantity of heat lost by radiation, convection, and conduction from the apparatus.
A.H._1 = the absolute humidity of the air entering the apparatus.
A.H._3 = the absolute humidity of the air leaving the apparatus.
h_2 = the heat content of the water supplied at t_2.
$h_{m3} - h_{m1}$ = the increase in the heat content of the mixture, per pound of dry air.

$$= 0.241\,(t_3 - t_1) + \text{A.H.}_3\,(1059.2 + 0.45\, t_3) - \text{A.H.}_1(1059.2 + 0.45\, t_1)$$

All these equations may be solved with the aid of steam charts or tables and a slide rule. The solution will take more time than when psychrometric charts are used, but the effect of all variables can be included in the solution.

The Ferrel formula may be graphically solved in a number of ways, as shown in the two accompanying solutions, thereby eliminating the necessity of using steam tables or charts. Fig. 8 is a network chart and Fig. 9 an alignment chart solution of this equation. Fig. 8 is intended for low temperature use.

With all of the psychrometric charts that have been devised, and with so few fundamental thermodynamic equations, the engineer should have little trouble in solving the common problems in psychrometry.

Welding Copper and Its Alloys

THE welding of copper at first presented difficulties which bid fair to retard the growth of the process in the fields in which this metal is used. However, investigation showed the low strength and ductility of welded commercially pure copper to be caused by the presence of minute particles of cuprous oxide which were segregated by the welding temperature in zones adjacent to the weld. It was found that by using completely deoxidized metal and welding rod, approximately 70% more strength and three times as much ductility was obtained.

With deoxidized copper and welding rod the welding technique is very similar to that employed for steel. However, the welding head should be one or two sizes larger than for a similar thickness of steel because of the high heat conductivity of copper. Where possible it is best to cover the work with asbestos paper in order to reduce heat losses to a minimum. Large sections, and small parts, if it is practicable, should always be preheated to a dull red. No flux is necessary with pure copper. Since the melting point of copper is lower than that of steel, the blow-pipe must be handled more rapidly than is possible with steel of similar thickness.

A satisfactory method of repairing copper apparatus, and in many cases in the manufacture of such equipment, is bronze-welding. This procedure is especially well adapted to copper which may contain impurities that would result in weak copper welds. The bronze weld adheres to the surface of the material with a bond as strong as the base metal. In repairing a break, the parts are locally heated with the blowpipe flame, bronze welding rod and brazo flux are applied, and the weld is built up. The joint should be finished by cleaning with a wire brush.—*Oxy-Acetylene Tips.*

Applications of Radiant Heating

By T. NAPIER ADLAM†

FOLLOWING Mr. Widdows' innovation of heating with pipes fixed below the floor, Messrs. G. N. Haden & Sons, of Trowbridge, conceived the idea of creating the same conditions by using hot air as a heating medium and circulating it through a series of ducts under the floor.

Undoubtedly, their idea had its inception from a well-preserved historical heating system known as the "hypocaust" which the Romans constructed in 55 A.D. at the Roman Baths, Bath, situated within 10 miles of Haden's works. The Romans made charcoal fires and allowed the smokeless fumes and hot air to pass through flues under the floors and in walls, and obtained heat in this way.

The principle of Haden's system is somewhat similar but greatly improved upon, while the results are almost identical to those obtained with pipes under the floor. Perhaps the method will be better understood if I describe the details of construction in connection with the new cathedral at Liverpool.

Fig. 1 gives a plan and section of the formation of flues under the floor. A indicates a heater which consists of an iron casing over which the air is circulated by the fan B on its way to the main air duct C; here it divides into small flues D and then back into the main return duct E, direct to the fan. The whole system is sealed so that no air escapes into the building, or is lost in any way.

The base, or underfloor, is actually a concrete raft, and forms a base for the circulating flues. Concrete divisional walls F, about 12 in. deep and 10 in. apart, are built so as to connect up to the flow and return duct alternately. Some are grouped as indicated so that the air may pass along several adjacent flues and return through others. The area of the openings G into the main ducts are calculated according to the length and number of flues connected to give an even distribution over the whole area.

Slate slabs H are laid on the top of the flue walls. These slabs are 1¼ in. thick, sufficient to support any reasonable weight, and on the top of the slate are placed white marble slabs about ¾ in. thick, bedded down to form the finished floor of the cathedral. The whole floor is thus one large radiator, computed to be the largest single radiator in the world.

Flues are stepped up where the riser steps are formed into the chancel. This makes the chancel equally warmed with the rest of the cathedral.

The temperature of the floor is usually 66° to 68°, which is sufficient to keep the cathedral comfortable.

The great advantage of having the architecture unspoiled by radiators or grilles will be appreciated by reference to Fig. 5 which shows the interior of this beautiful building. There is no darkening of

† Consulting Engineer, Bethlehem, Pa.

Fig. 1. Plan of flues for underfloor heating system in Liverpool Cathedral.

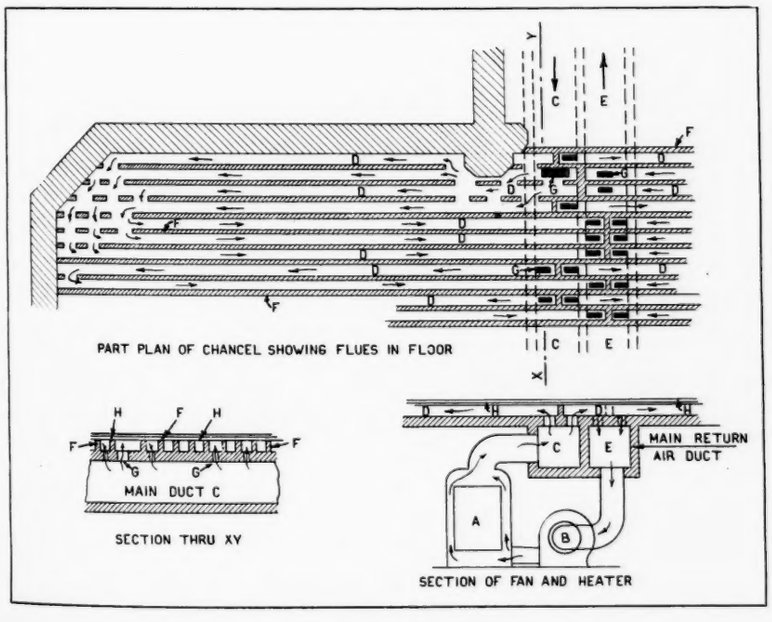
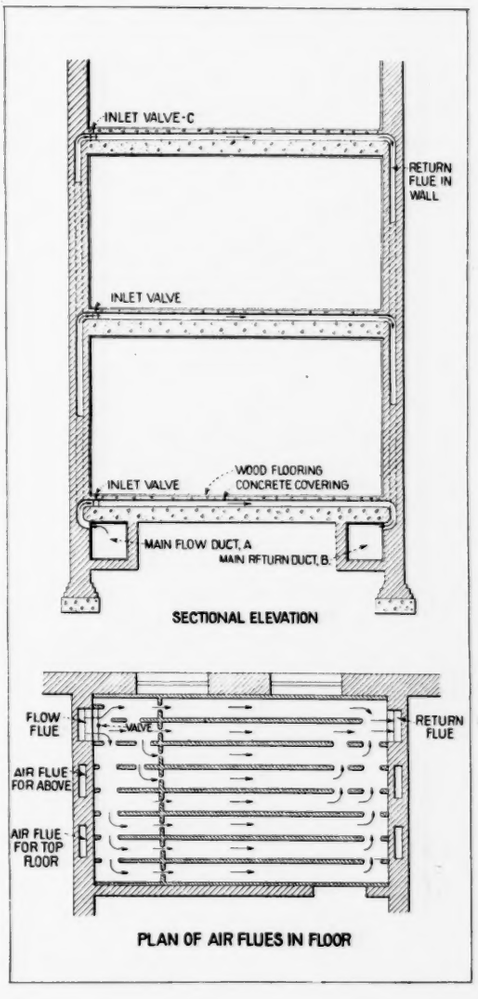


Fig. 2. Plan and elevation of warm air radiant heating system as applied to multi-story buildings.



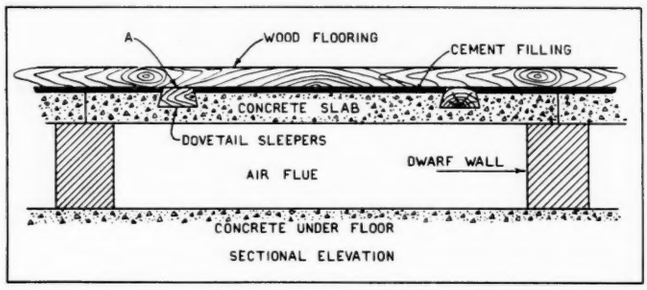


Fig. 3. Floor construction for warm air radiant heating system.

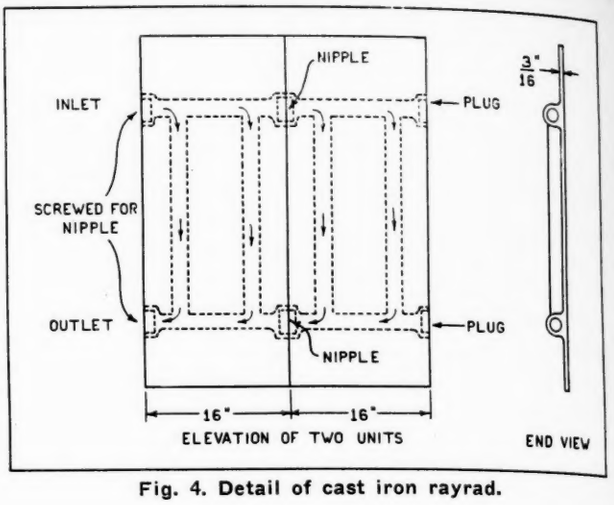


Fig. 4. Detail of cast iron rayrad.

the walls, and all that one can see of the heating system is a white polished marble floor. The building is free of the cold spots and draughts which are usually so common in buildings of this nature.

Some of the operating results will be of interest. The cathedral is 113 ft. high inside with a triforium 97 ft. high, where it is possible to make accurate observations of the air conditions at this high level.

When the temperature of the air 4 ft. above the floor was 60° it was found that the air temperature at the triforium level was 58½°, just 1½° lower at 97 ft. above the floor than at 4 ft. above the floor. It seems to me that no other method of heating now known could create such conditions in such a high building.

Although 60° was obtained in the above test, it has been found that 56° will give all the heat necessary to keep the cathedral comfortable.

If the oil fire is allowed to go out it takes 36 hr. for the temperature of the cathedral to fall 1° in cold weather. In actual operation it has been found that if the fire is worked for a few hours each day, the temperature change is unnoticeable and the cathedral is always maintained in a comfortable condition. The time lag offers no disadvantage with a building of this nature, for the heavy masonry is a protection against any rapid internal change corresponding to a temperature change outside, and therefore the atmosphere inside remains at a steady temperature.

Saving of fuel by this method of heating is without doubt very considerable, although there are no actual comparative figures available. After coke fires were used for a few years oil burners were introduced to enable the fire to be started and stopped at intervals, and the fuel saving amounted to 25%.

It may be thought that heat conducted downward from the air flues is lost, but this is not true, for when the circulating fan is stopped most of this heat is reserved in the underfloor and earth and is given back to the top floor, passing into the cathedral as radiant heat.

The advantage of the warm-air method of floor heating over the pipe system holds good only for very large buildings such as cathedrals and other memorial buildings. For smaller buildings the initial cost and operating costs are much less with the pipe method of floor heating.

The only part of the system that requires attention is the fan or heater, and these are housed in the basement where they can be attended to easily.

These advantages are undoubtedly worthy of consideration when dealing with buildings of artistic or historical value, for there are no pipes to leak, nothing to become choked, and nothing can go wrong with age.

The drawback to the system is the rather high initial cost and the extra cost of running a fan for circulating the air. It will, however, be observed that it is practically impossible to install such long pipes as would be necessary to reach the length or width of a large cathedral, and the risk of pipes leaking or becoming choked under such a floor is too great to ignore. Again the work of forming chases for risers, and the construction of spaces for the pipes with suitable means of access to the joints, would render the pipe system almost as costly to install as the warm-air system for such a building.

Cost of running the fan is greatly reduced by the possibility of infrequent running, as is found in practice, so that the disadvantages are not excessive when compared with the greater advantages gained in buildings of this class.

The system has also been successfully applied to hospital wards and operating amphitheatres as well as to other buildings.

With buildings of several floors, the layout is similar to that illustrated in Fig. 2. The construction of the underfloor is of concrete as before, but the air flues are usually about 4 in. deep because of the smaller amount of air to be carried. The covering is of concrete 1½ in. to 2 in. thick, sometimes cast over solid, and sometimes laid in slabs. If a board flooring is to be laid on the top of the concrete, wood dovetail sleepers, which are used for nailing down the boards, are cast into the concrete as shown at A, Fig. 3. The dovetail sleepers are left about ⅛ in. above the concrete and planed off true afterwards. A layer of thin cement is rendered over the concrete to fill up the space between the concrete

Engineers in this country when discussing radiant heating usually think either of the common electric or gas-fired radiant heaters or of the English system using hot water. However, in this article the author describes an application of radiant heating using a warm air system, as installed in the Liverpool Cathedral. He also tells of the quite popular (in England) rayrad heaters, and of the electric radiant elements used in that country.

and the boards to insure good contact, after which the wood boards are nailed down with secret nailing in the usual way.

There is never any trouble with shrinkage if the wood flooring is well dried before being nailed down. Teak has been much used for this purpose.

Wood blocks or any composition flooring may be used instead of the boards, providing there is no material such as bitumen, which will become plastic with the heat.

Referring to Fig. 2, A and B are the main flow and return ducts below ground level from which is connected a series of vertical flues, joining up to the flues under the floors of the various rooms. One vertical flow and one vertical return are provided for each room, thus forming a complete circuit for each room. A sheet metal valve C is fixed at the opening of the flue to each room so that the heat can be regulated as found desirable.

With the upper rooms it is found essential to have the underfloor well insulated, so as to prevent the heat from descending, as this may overheat the room below. The downward effect with hot air circulating in the floor spaces is more pronounced than with the pipe method of floor heating.

When the main ducts A and B are constructed underground it is necessary to have them lined to prevent moisture being drawn in from the adjacent soil. Airtight sheet-metal linings or ducts should be employed, as the hot air travelling along porous ducts gradually absorbs the moisture from the soil, and eventually builds up a highly saturated condition, so that when the air reaches the cooler surfaces in the floor space it reaches its dew point and deposits water. This in time percolates through the underfloor to the ceiling below, where it forms small stalactites and ultimately drips on the floor. This is a point that must be guarded against, but with the necessary precaution with the main ducts, it can be entirely avoided.

For ground floor heating only there is no need for any such precaution as the trouble could not arise.

In operating amphitheaters of hospitals, where the temperatures are necessarily high, it is customary to pass the air through flues formed in the walls as well as the floor, and by constructing such a room with white

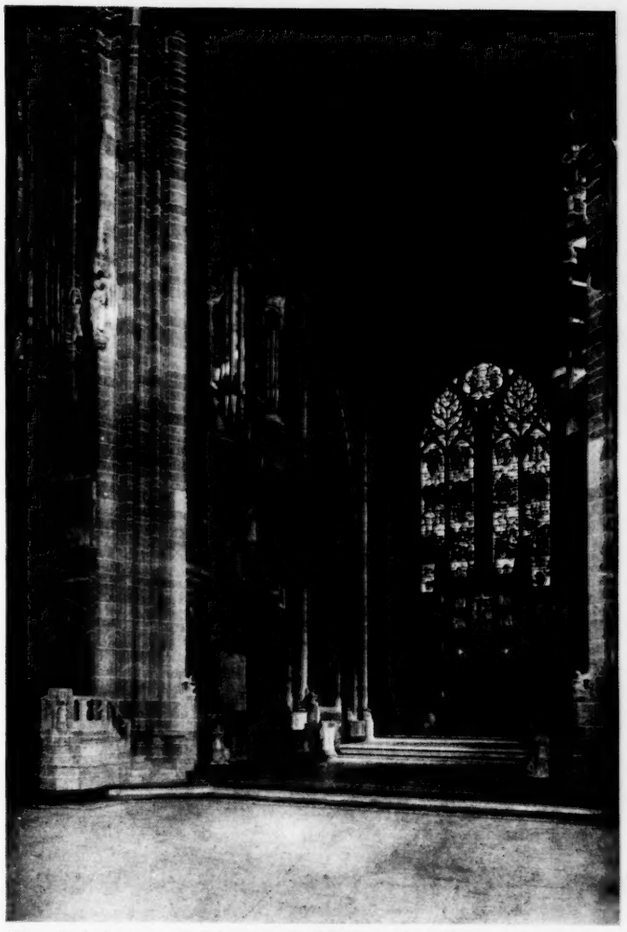


Fig. 5. Interior of Liverpool Cathedral. When the air temperature is 60° 4 ft. above the floor, it is 58½° 97 ft. above the floor.

marble slabs covering the flues on the walls and floor, an ideal finish, capable of being washed, is obtained, while the floor and wall areas are left free for instrument stands and other equipment.

The effect for operations is ideal, as the absence of air currents, with a moderate and constant stream of heat rays, is safer to the exposed organs than with any system where air currents are created.

A further advancement in the methods of producing

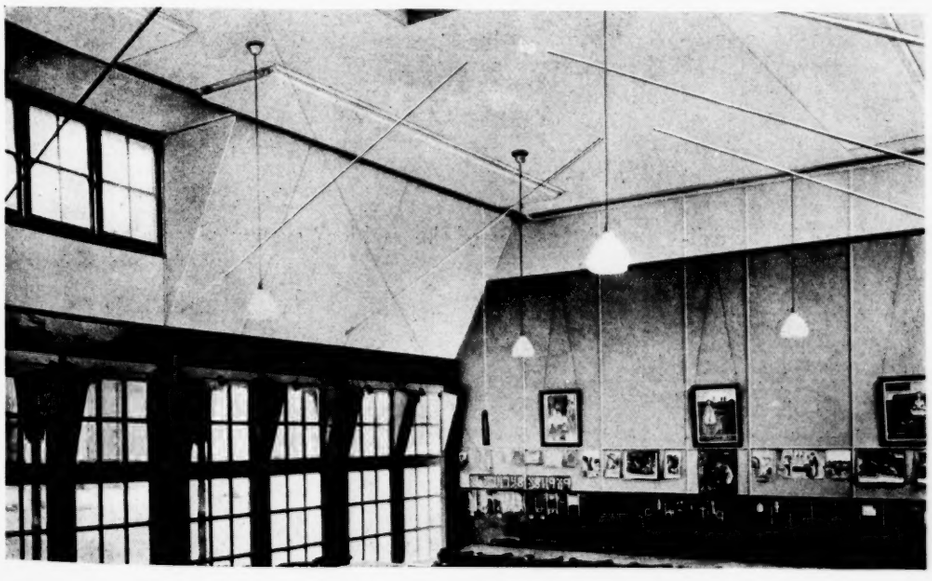


Fig. 6. View of a radiant heated schoolroom, showing rayrads in the ceiling.

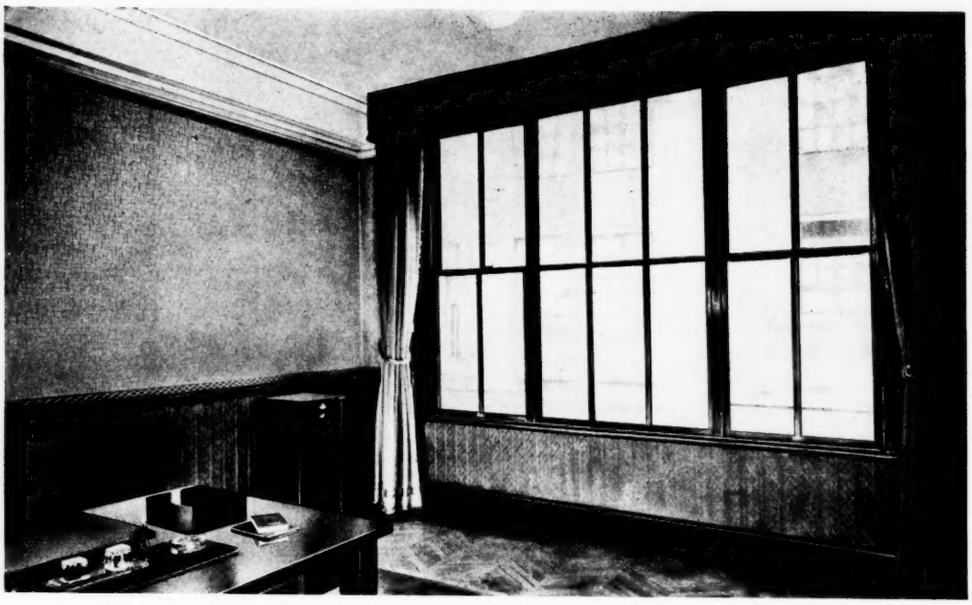


Fig. 7. The rayrads forming the dado under the window in this office have an ornamental surface.

thermal radiations was made by A. H. Barker by introducing the unit method of building up flat metal radiating surfaces. This is commonly known as the rayrad and was patented by him in 1925. The plain type of rayrad is illustrated in Fig. 4.

These are cast as flat iron plates, about 3/16 in. thick, on which are cast two water or steam ways, about ½ in. or ¾ in. internal diameter, through which the heating medium is circulated.

Rayrads are made at present in three sizes, viz., 16 in. long by 18 in., 24 in. and 30 in. wide, and are jointed together by ordinary right and left hand nipples, similar to radiator sections. Consequently, they can therefore be assembled into large plates up to 9 ft. long in widths suitable for the intended locations.

Rayrads can be installed in numerous ways

These plates can be installed in many different ways to suit the building. For instance, they can be placed flat against the finished wall or ceiling with a moulding fixed around the edge, which gives an appearance of a raised flat panel. When so installed they can be adapted to an old building without entailing a large amount of alteration work.

Usually, however, and especially for new buildings, the rayrads are placed in recesses so that the surface of the plate is flush with the surface of the wall, or ceiling. It is always advisable to have a little space between the edge of the plate and the plaster to allow for expansion. The space can be covered with a suitable bead or moulding. Surfaces of the rayrads can be covered or decorated to harmonize with the rest of the room and rendered unnoticeable.

Fig. 6 shows a room with rayrads placed in the ceiling.

In other cases the plates are cast to shape and formed into a complete or partial dado round the walls as illustrated in Fig. 7.

To obtain an almost perfect replica of woodwork the plates are cast from patterns made like ordinary oak panels, in which oak graining has been incorporated, so that when suitably colored they have the exact appearance of genuine oak.

The flat panels can be used between the windows of a room to any suitable height, or they may be made any length to install under the windows, as illustrated in Fig. 8.

The writer has also used these very successfully for institutions for mental treatment. In fact, any kind of radiant heat is suitable and desirable for mental patients because it is impossible for them to recline on the surface as they do where ordinary hot radiators are provided, and the absence of any kind of grille eliminates any inclination on the part of the patient to insert rubbish or to expectorate into the grille.

The temperature of the metal surface is considerably lower than the heating medium used, for the heat is conducted over the whole plate which gives it a moderate mean temperature.

One advantage of the metal plates is that steam may be used as a heating medium, whereas with pipes embedded in the plaster only hot water can be readily used. Steam makes it possible for rayrads to be used for any height of building, and with a proper system is very successful and suitable for our quickly-changing climate.

Surface temperature should be constant over whole area

When controlling the room temperature it should be kept in mind that it is imperative with thermal radiations to keep the surface temperature over the whole area as constant as possible. The mere throttling of steam gives very indifferent results, for with this method we obtain one small portion of the surface highly active in thermal radiations, while the remaining surface will be cool, causing it to absorb rays instead of emitting them.

The writer's experience has been that the expanded dried vapor of the "selvac" system gives a remarkably even temperature over the whole area with a wide range of temperatures, both with metal plates and steam coils.

With radiant heating a wide range of effect can be produced with a restricted range of surface temperatures. Heat given off as convected heat from a hot surface varies approximately as the 1.25 power of the absolute temperature difference, whereas the heat given off as radiant heat varies approximately as the difference between the fourth powers of the temperatures.

Advantages of the metal plate system are that it can be installed after the building has been erected, is ex-

posed in case of leakages, and can always be examined and removed for repairs when necessary. It can be extended like any ordinary system of heating, and the sizes are such that the heating surfaces can be arranged in a wide variety of sizes and positions.

If used within the permissible limits and with good control, the flat panels may be used as a cooling device for absorbing some of the radiation from our bodies in extremely hot weather, thereby creating some of that cooling effect we find so refreshing in a room or cave where the walls are cooler than the surrounding air. We will, however, consider this aspect further later.

Electrical radiant heating available in different types

So far we have considered the question of using either steam or hot water as a heating medium, but the full advantage of radiant heat can also be obtained by using panels electrically heated. As the supply of electric current becomes cheaper this method of heating will come more to the front, because it has so many advantages.

Electrical installations may use the cast iron rayrad as described previously but instead of using water or steam in the channels of the casting an electrical resistance is constructed so that it can be threaded into the electro-rayrad after it is assembled. This makes a convenient and adaptable fitting having all the attributes of the parent fitting, since the surface is maintained at the same temperature.

Other makes of electric panels are manufactured, among which are those made of light asbestos sheet, faced with cork, on which is placed a layer of composition ¼ in. thick, and in which is embedded a grid of insulated wire. The panels are made in stock sizes for various currents. They can be installed flush with the face of the walls or ceiling, as described for other flat elements.

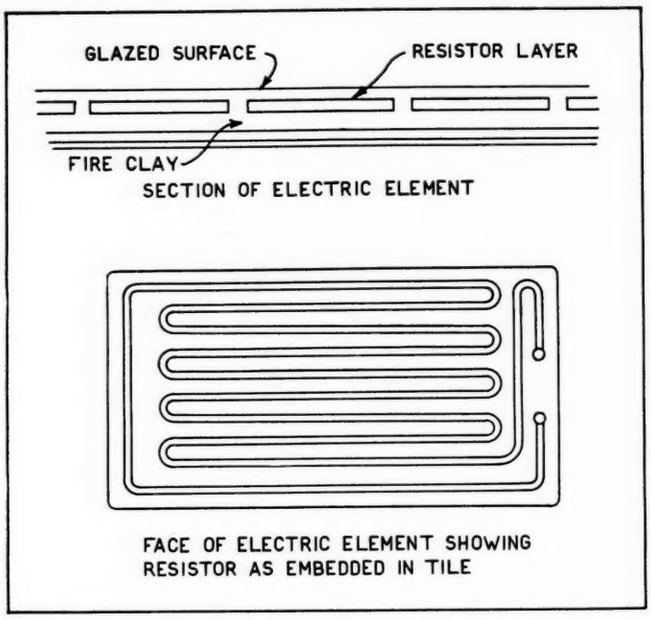
Many unique methods have been adopted for producing thermal radiations, such as concealing the elements behind large glass mirrors or in folding screens. Radiant heat has also been produced by the use of textiles in which a continuous wire is interwoven with the cloth. The wires are used as the warp and the wool or silk as the woof. The current passing through the wires keeps the surface at a uniform temperature. With suitable designs these can be used as pictures which may be hung at any angle, or they may be made into tapestry for hanging on the walls. Such methods have the disadvantage that there is the risk that a possible fracture of the electrical conductor might occur in which case there is danger of receiving a shock or of starting a fire.

More recently the Morganite electrical system of radiant heating has been introduced. The panels consist of a glazed fire-clay tile ⅝ in. thick in which is embedded a graphite resistor ribbon. Fig. 9 shows a section of one of these elements. They are usually made 25 in. x 13 in. and loaded to consume 1,750 watts (equivalent to 5975 B.t.u. per hr.) with a safe maximum surface temperature of 550° F.

These elements are usually placed at various angles in the room, both at the sides and in the corners, so as to throw the rays in definite directions. It is claimed that, for rooms of less than 30 ft. span, the best possible distribution is obtained when the elements are mounted on the walls 8 ft. high and at an angle of 30°. For rooms of large span it is found desirable to supplement the radiating elements on the side walls by elements suspended from the ceiling. These may be employed as flat plates, or as combined lighting and heating units.

With elements at such a high temperature and exposed in free air the tendency is to create a large amount of convected heat. Also, with such high surface temperatures, particles of dust get split up and form ammoniacal vapors, but the most serious result is the concentration of rays.

Fig. 8. Rayrads in this hall are located in the pilasters between the windows and at the white rectangles on the mezzanine, facing the camera.



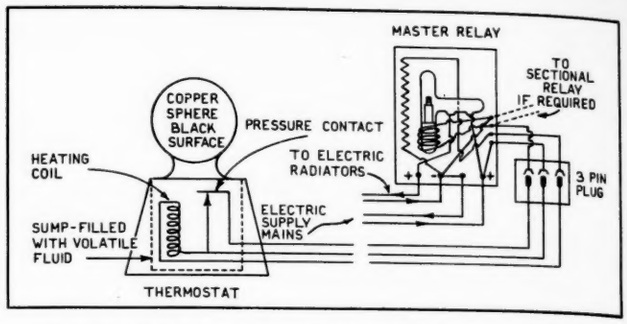


Fig. 10. Detail of Morganite radiation thermostat.

Fig. 9. Section of a Morganite electric element used for radiant heating.

We have seen that within practical limits the rays travel in straight lines, and the effect of intensified rays emitted from a comparatively small surface would be to have beams of high power instead of an evenly distributed flow of rays. The thermometer may not detect these beams but the body is susceptible to them, and the great advantage of thermal radiations seems to lie in the even distribution over the body.

Radiation thermostat loses heat in manner similar to human body

Connected with the Morganite system is an ingenious device for controlling the thermal radiations as desired. This instrument is known as a radiation thermostat and is illustrated in Fig. 10.

It consists of a blackened copper sphere supported upon a base in which is housed a cylindrical sump containing a volatile liquid.

An electric contact inside the sump is operated by any variation in pressure which takes place inside the sphere, and a small heating coil supplied by a constant input of 3 to 10 amperes is inserted in the liquid to maintain a constant evaporation, by keeping same at a temperature of about 75° F. (which is assumed to be that of the average person's clothes).

As the vapor rises from the sump at a constant rate into the sphere, the rate of condensation will depend upon the heat losses from the sphere and, as this is subject to the effect of both radiation and convection in a similar manner to the human body, it is considered a means of actuating the heating elements and automatically maintaining the desired degree of comfort in the room.

If the heat losses from the sphere are large due to a low air temperature or cold wall and window surfaces the vapor is condensed quickly and the pressure reduced.

This acts on the diaphragm and maintains a good supply of heat until the radiation or convection losses are compensated for, and the required degree of comfort obtained, when the electric supply will be gradually reduced. If the conditions tend to become too warm the extra pressure inside the instrument will shut off the supply entirely.

The whole equipment consists of the thermostat and master relay and, if necessary, one or more secondary relays constructed to carry up to 50 amperes.

The master relay consists of a vertical tube from the center part of which projects a horizontal arm containing two contacts. A quantity of mercury, in which floats an iron rod, is sealed in the vertical tube, the lower end of which is surrounded by a solenoid controlled by the thermostat. When the solenoid is energized the iron is attracted downwards, thus displacing some of the mercury into the horizontal tube and completing the circuit between the two contacts. The master relay is also fitted with a comfort coil which controls the operation of the thermostat contacts. The varying comfort conditions necessary for different classes of buildings can be accomplished by changing the comfort coil.

A cut-out is incorporated in the thermostat unit for breaking the circuit of the heating coil of the sphere when the surrounding air temperature exceeds a certain value.

The thermostat is always placed on a table or in some position where it is subjected to the same conditions as the occupants of the room, but the relays may be placed in any convenient position.

The radiators are automatically switched on and off depending on the surface temperature of the sphere, which is set for 75° F.

Sphere gives definite degree of comfort

As the sphere is affected by the radiations it receives, as well as by the surrounding air temperature, it is intended to give a definite degree of comfort.

The effect of switching on and off cannot, however, be as satisfactory in principle as the gradual modulating of the surface temperature to meet the varying conditions. If we are dealing with a large mass, as with a heavy construction of masonry, where the heat capacity is sufficient to maintain a fairly constant surface temperature, even though the application of heat may be intermittent, it gives satisfactory results, but where the mass is small and there is rapid cooling of the surfaces, intermittent supply of heat is not satisfactory for meeting physiological requirements.

Abstracts . . .

Reviews and Summaries of . . . Current Papers, Books and Pamphlets

The Realm of the Air

By Charles F. Talman

307 pages, illustrated, cloth bound, 6 in. x 9 in. Published by Bobbs-Merrill Company, price $4.00.

A book about the weather written by an authority on the subject who takes occasion to explain the causes of both the usual and the unusual phenomena.

The author writes in a most interesting popular style and uses no technical terms without making them clear. His close familiarity with his subjects is evident throughout.

Subjects of particular interest are his presentation of weather measurements, the ideas of atmospheric comfort, predicting weather, and the formation of atmospheric ice and snow.

All who use atmospheric air for ventilation or air conditioning or who have interests even bordering on the subject of air will find the book both informative and entertaining as general background reading without fatiguing technical detail.

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Steam Condensation an Inverse Index of Heating Effect

By A. P. Kratz and M. K. Fahnestock

A.S.H.V.E. paper, Swampscott meeting, June, 1931. About 2000 words, 2 line drawings showing testing plant, 4 photographs of radiators tested, 2 charts and 1 table of the results.

Results of a cooperative project between the University of Illinois and the society. Studies at the radiator test plant undertaken to make a comparison of the performance of several types of direct cast iron radiators using steam as the heating medium, when the temperature of the air in the test room was maintained at approximately 70° F. at the breathing level, with the performance of the same types of radiators when the temperature was maintained at 68° at a level 30 in. from the floor.

Four types of direct cast iron radiators were tested and the table shows a summary of the results.

Radiator Type	Temperature Difference Ceil-Floor	Steam Condensation (lb. per hr.)	Ratio of each value in columns (2) and (3) to preceding value. Temperature Difference	Steam Condensation
(1)	(2)	(3)	(4)	(5)
5-tube	21.6	6.68	.....	.....
3-tube	17.5	6.48	0.810	0.970
1-tube panel	13.8	6.12	0.788	0.943
3-section wall	10.8	5.50	0.782	0.900

The following conclusions were drawn by the authors:

1. It is apparent that maintaining a temperature of 68° at the 30 in. level is a more acceptable standard for stating conditions under which direct radiators shall be tested in the type of plant used than maintaining a temperature of 70° at the breathing level.

2. With 68° at the 30 in. level, the steam condensation obtained in the test plant used seems to be a measure of the effectiveness of the direct radiators tested in providing for human comfort, or, more briefly, condensation becomes an inverse index of *heating effect*.

●

Modern Combustion, Coal Economics, and Fuel Fallacies

By Clarence V. Beck

382 pages, profusely illustrated, bound in Fabricoid, 7 in. x 10½ in. Published by "Mid-West Coal Retailer," Chicago, $3.00, postpaid.

The author is an executive connected with commercial coal companies engaged in both the production and marketing of coal. As might be expected he is well sold on the present usefulness and future prospects of coal. In fact, one cannot help but gather the impression that he has but little patience with attempts to demonstrate that other fuels have either any worthwhile field or any especial prospects for the future. This tendency to over-glorify coal is probably the weakest point in the book.

The author's collection and tabulations of statistics and figures is astonishing. He seems to possess the faculty of producing any figures he needs with the slightest effort. The book is replete with tabulations, calculations from data, numerical analyses and graphs and charts. In some cases the results produced by the use of the statistical information may lead one to suspect that perhaps all the factors have not been fully taken into account, especially when he makes estimates of future trends by the simple process of assuming figures.

Considerably over half the book is devoted to the general subject of modern combustion which is treated in

five sections. The section which deals with the chemistry of combustion and with the usual calculations is interesting largely because of the free and original use of illustrational material. The author's discussion of the degree day as an estimating unit is weak and shows a lack of understanding of both the origin and proper use of the unit.

Under the heading of fuel fallacies the author pays his respects to the propaganda favoring the ultimate use of oil and natural gas. While one may not agree in all particulars, nevertheless the presentation of the subject does show the author's clear grasp of the essentials. He produces a strong and forceful story.

He advocates the use of isolated plants for the production of power and heat and argues that they are a logical development. He quotes an instance in which a plant had requirements for both process steam and power in which it appears that a suitable solution was found by an engineer by the simple process of increasing the boiler pressure until he had enough power to meet the requirements with enough heat in the turbine exhaust to provide the process steam needs. Just how this arrangement was worked out is not described and nothing is said about the time of occurrence of peaks in the two requirements. He fails to mention in his discussion the possibility of interconnected utility solutions for this kind of problem.

On the whole the book is one which is likely to be of considerable value to those engaged in the coal trade as it is full of ammunition, but is not to be considered as a technical reference unless one is in a position to make the necessary allowances for the author's enthusiasms.

●

Essential Elements for Determining Heating Plant Requirements

By F. B. Rowley

A.S.H.V.E. paper, Swampscott meeting, June, 1931. About 5000 words, two figures, one table.

A thorough discussion of the factors which affect the problem of the designer in predetermining the plant requirements. The paper shows that much very desirable information is still not available to the designer as he makes his plans. The author stresses the importance of proper consideration being given to heat utilization methods after the heat has been released within a building. He also concludes that more study should be given to weather bureau records, and that the heat capacity of walls should receive greater attention in setting up methods of computing requirements.

The paper states that the four following factors bear on the question of the heat supply.

1. Air temperatures within the space to be heated.
2. Heat utilization or the efficiency of the heat distributing system used.
3. Unit of measure by which heaters are rated.
4. Method used for calculating losses from the building.

Each of these four factors is separately discussed and the author concludes that:

1. The air temperature required may be taken as 70° as a mean for design purposes but that consideration should be given to surface temperature and to the point at which this temperature is assumed to exist.
2. A high heat utilization factor may be obtained if the designer will take into account the heat distribution which he can obtain with factors under his control, such as location and selection of heating surfaces.
3. Methods of arriving at a unit of measure for heaters are not now wholly satisfactory, as each leaves something to be desired.
4. That the duration of weather conditions should be considered as well as their magnitudes, while the thermal properties of walls should be used with care in making calculations. Variations in the use of existing information on air leakage reflect the wide divergence between expected and actual results.

The paper adds little information to that already in existence but it does approach the subject from a different point of view than the traditional one.

●

Using Gas-Vapor Mixtures for Heating Purposes

By C. A. Dunham

A. S. H. V. E. paper, presented at the semi-annual meeting, June, 1931. About 4000 words, 5 drawings, 2 photos.

It is common knowledge that it is possible to design gas-fired heating equipment which will operate at thermal efficiencies higher than result from the use of the boilers and furnaces now in common use. Many such designs have been proposed. An objection has been that the extraction of heat from the products of combustion causes the temperature of the flue gases to be so reduced that condensation takes place in the flues, often resulting in destructive corrosion of the chimney, boiler or furnace flues and breeching.

The method proposed in this paper is to burn gas in the presence of water at gas pressures slightly below atmospheric and convey the resulting mixture of the products of combustion and steam to the radiators. The author states that his tests show that the corrosion in the pipes is not severe, and that the penetration is slight, especially if copper steel alloy is used. In operation, non-condensable gases, after passing through the radiators, are discharged to the flue by means of a pump, the surplus water passing to a drain.

The generator is the basis of the design. In the base is placed a circular refractory. The gas burner projects into the refractory and the flame is given a whirling motion by reason of the burner being placed off center.

The generator has a double wall, the dome of the inner wall being open directly over the center. When the water level between the walls rises so as to overflow the water drips into a pan below the opening, the pa

in turn overflowing on a flash plate which is slightly cupped to hold a small quantity of water.

Advantages claimed for the arrangement include the elimination of loss in heat transfer through metal in the generator, and reduction of heat lost in the flue gases, with consequent overall efficiencies around 90%.

●

Sizing Pipes and Orifices for Gravity Hot Water Heating Systems

By E. G. Smith

A.S.H.V.E. paper, Swampscott meeting, June, 1931. About 12,000 words, 11 figures, 8 tables.

Results of studies at Texas A. and M. College by the author and carried on cooperatively with the society to arrive at economical pipe sizes instead of those recommended as the result of previous work. It is felt that the tables presented in the paper may be used for sizing pipe for either gravity or closed hot water systems.

The paper describes the tests in some detail, includes tables for use in design, gives detailed step-by-step directions for procedure, discusses the formulas used in calculating the tables, and a set of questions and answers on the subject.

●

Does School Ventilation Aid Health?

By R. L. C. Butsch

The American School Board Journal, July, 1931. About 5000 words, 7 tables.

A study of certain factors in connection with the relationship between two types of ventilation in schoolrooms and absenteeism due to respiratory illnesses, a continuation of a study carried on by the author in the suburbs of Chicago in 1927-28, sponsored by the New York Commission on Ventilation. The author is professor of education at Marquette University.

The study covers only a comparison between fan-gravity and window-gravity methods of ventilation. The criticism that there is difficulty in obtaining strictly comparable groups of children under the conditions of the investigation has been met by obtaining groups which are claimed to be comparable so far as the factors of age, nationality, and social or occupational status is concerned. In order to compare the absences in each grade, buildings with at least two rooms in each grade were chosen, one of the rooms being operated with the fan-gravity system and the other ventilated by the window-gravity method.

In addition to the absence records, which were kept on special forms and investigated by the school nurse, measurements of physical conditions within the room were recorded as follows: air movement at the exhaust, temperature at desk and floor levels at seven or eight points in the room, and kata-thermometer readings at the same points.

Rates of absences were analyzed by semester, by school, by rows of desks vertically in the room and by rows horizontally, by individuals, and by grade. The table shows the percentage of absences due to respiratory illness by grade.

Percentage of Absence Due to Respiratory Illness by Grade

Window-Gravity Rooms

Grade	*1st Sem.*	*2nd Sem.*	*Year*
1	6.18	5.99	6.08
2	5.54	4.01	5.58
3	4.67	4.64	4.66
4	3.15	2.81	3.00
5	4.22	2.02	3.34
6	4.73	2.31	3.76
1-6	4.74	3.77	4.32

Fan-Gravity Rooms

Grade	*1st Sem.*	*2nd Sem.*	*Year*
1	7.75	4.30	5.80
2	4.43	3.77	4.05
3	5.12	2.73	3.62
4	4.85	2.37	3.47
5	4.32	2.06	2.96
6	4.08	2.08	2.93
1-6	5.28	2.98	3.94

The conclusions reached by the author are:

"1. Under the conditions of the present study there was no significant difference between the percentage of absence due to respiratory illness in rooms operated on an approved type of fan-gravity ventilation, and that in rooms operated on an unsatisfactory type of window-gravity ventilation.

"2 The correlations between individual pupil records of absence due to respiratory illness were not very significant in any case. They were in general higher where the pupil was in a different room and under a different system of ventilation for the two semesters.

"3. In the window-gravity rooms the middle row had the largest amount of absence due to respiratory illness per pupil; and the rows next to the walls the least amount.

"4. In the fan-gravity rooms the least amount of such absence was found in the center row and the row next to the inner wall.

"5. The center section of the rooms had a smaller amount of such absence that did either the front or the rear section, in all groups and ventilation types compared.

"6. When the rooms are divided into fifteen sections there was found to be no significant correlation between the amount of such absence in the particular sections in the two semesters.

"7. There appeared to be little, if any, significant relationship between the rate of absence due to respiratory illness in any particular section of the individual room, and the physical factors of floor-level temperature, desk-level temeprature, and kata-thermometer reading for that section."

Two points in the study are particularly interesting. One is that for the year as a whole the percentage of absences with the window-gravity rooms was 3.49 as compared with 3.36 with the fan-gravity rooms. The other point is that, although the criticism of previous studies in regard to race, age, nationality, etc., was met the still more important criticism that respiratory illness may not be a criterion of the efficacy of a ventilation system has been ignored.

Your Everyday Problems

Mr. Hanburger will be glad to answer your problems relating to installation and operation of heating and ventilating systems, and wherever possible will give the reasons for his suggestions. Letters will be answered direct to the inquirer and in some cases published anonymously. If sketches are included they should be clearly drawn. Write Mr. Hanburger care of HEATING AND VENTILATING, 521 Fifth Avenue, New York.

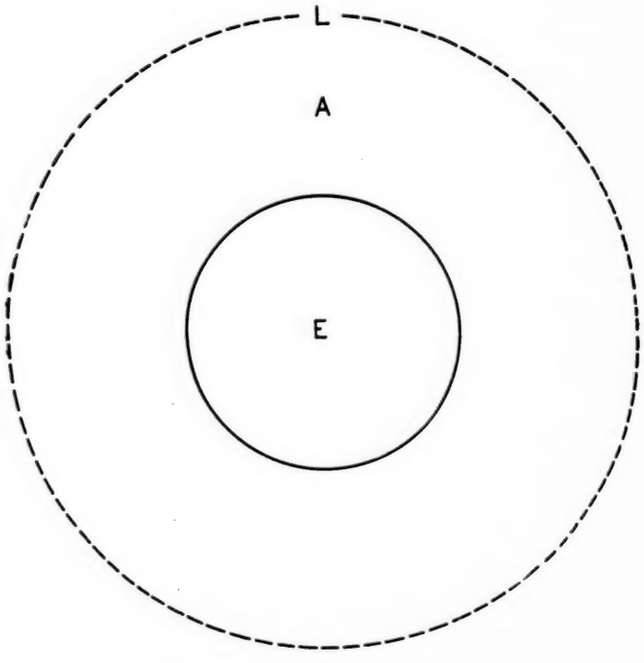
Conducted by FRED W. HANBURGER

QUESTION 10. Can you give me a short method of finding the weight of air at any temperature? In studying the density I became confused in the meaning of the value of 53.35 as given in the formula $PV = RT$.

ANSWER. Possibly the shortest method of obtaining the density or weight per cubic foot of air is to divide the constant 39.67 by the absolute temperature of the air. Thus, the weight per cubic foot at

$70° = \frac{39.67}{460 + 70} = 0.075$ lb. At 120° it is $\frac{39.67}{460 + 120} = 0.069$ lb., etc.

The derivation of the constant comes from the same value of R which is confusing you. Sometimes much of a physical law may seem hidden in the shorthand



expression of its formula and we can get a clearer view by making a mental picture of conditions as they may familiarly exist or as we may imagine they do exist. In the drawing let E represent the earth and A the blanket of air surrounding it. Let us assume for the purpose of argument that the air has the same density throughout. It will then have a defined limit as shown by the line L. This ocean of air by its weight creates a pressure of 14.7 lb. per sq. in. or 2116.8 lb. per square foot at the earth's surface. Knowing the density of air at any temperature we could determine the depth of this ocean of air. Assuming a temperature of 70° throughout and taking the weight of 1 cubic foot of air at 0.0749 the height of the air column must be $\frac{2116.8}{0.0749} = 28261$ ft. under our assumed conditions. By Charles' Law we know that with the same pressure the volume of a gas will vary as its absolute temperature. Therefore, if we reduce the temperature of our column of air to 1° absolute it will shrink to $\frac{1}{529.6}$ of its original volume. The height of the air column will then be

$$\frac{2116.8}{529.6} = 53.35$$

The line L would then be only 53.35 ft. above the earth's surface and if, under these conditions, we went to the sixth story of a building we would be at a relative greater height than that attained recently by Professor Piccard in his Stratosphere, where the principal source of light would be that reflected from the earth and from which we could see the stars shining in daytime.

The value 53.35 just obtained is the value of R for air and it may help you to look upon it as the height of an atmospheric air column of equal density at a temperature of 1° absolute. The weight of 1 cubic foot of this air must then be

$$\frac{2116.8 \text{ lb.}}{53.3 \text{ ft.}} = 39.67 \text{ lb.}$$

Dividing the latter figure by the absolute temperature then must give the specific weight at that temperature.

QUESTION 11. When steam for heating purposes must be carried underground for a great distance, is it advisable to have the steam superheated to take care of any condensation that may take place in the underground pipe?

ANSWER. In general it is not practical for great distances and modern practice tends toward the use of traps and drips to eliminate the water of condensation. A little thought and calculation will make this clear.

Assume an underground low pressure main supplying 1000 sq. ft. of radiation. To avoid undue pressure loss, a 2½ in. pipe would be the smallest that could be used and with 500 lin. ft. there would be 375 sq. ft. of radiating surface. With good insulation there will be a heat emission of at least 50 B.t.u. per sq. ft., making the total heat loss equal to

$$50 \times 375 = 18750 \text{ B.t.u.}$$

which must be supplied by the superheat.

The superheat must be contained in

$$\frac{1000 \text{ sq. ft. radiation}}{4} = 250 \text{ lb. steam.}$$

Taking the specific heat of steam at 0.48 there would be 0.48 x 250 lb. = 120 B.t.u. absorbed by each degree of superheat and the superheat needed must be

$$\frac{18750 \text{ B.t.u.}}{120 \text{ B.t.u.}} = 157°,$$

not impractical for this case. Using high pressure steam a larger pressure drop could be employed resulting in smaller pipe, and consequently less radiating surface, but the heat emission per square foot will be greater.

QUESTION 12. I am writing to you to settle a dispute. I am the owner of a 4-story loft building and three years ago I had a steam heating system installed which gave very good service for two years but last winter we could not get the lower floor warm at all. I am trying to hold the contractor responsible even though he has been paid in full. Surely a system should not go to pieces in two years. He claims that the new tenants have the doors open too long while they are loading and unloading their trucks. I timed this and found that the large doors were open about 15 min. four times a day while they were rolling in barrels of oil and turpentine from the trucks and loading the trucks with paint cans. Other stores have the doors open that much. I know that the contractor will abide by your decision, and so will I. H. A. S.

ANSWER. The fact that the system gave good service the first two years indicates that it was adequate to heat the building. It is hardly possible and not probable that one part of it should deteriorate so much in that time and its failure must be due to some other cause. I am glad that you mentioned the matter of the trucks, the new tenant and the paint because there, no doubt, is where the trouble lies, not so much on account of the open doors as to the nature of the cold material being constantly brought into the store or warehouse.

I hope that I may be able to again establish pleasant relations between you and the contractor with the following explanation. Your contractor estimates and designs his systems by a heat measure called the British thermal unit and it takes, roughly, about one-half of one of these units to raise the temperature of 1 lb. of turpentine, oil or paint one degree. All the material that is brought in on a cold day will have the same temperature as the outside air and as it warms up in the room will leave the room colder. Let us assume that the temperature outside and of the material is 10°. Then to have it reach the room temperature it will require a rise of 60° and take

$$\frac{1}{2} \times 60 = 30 \text{ heat units}$$

for each pound of material. If each truck brought in one ton the total for the 4 trucks will be 8000 lb. and will need

$$8000 \text{ lb.} \times 30 \text{ units} = 240{,}000 \text{ heat units}$$

If this warming up took 10 hr. the material would be absorbing and robbing the store of 24,000 units per hr. It would be even greater than this when the material was coldest.

Each square foot of radiation that your contractor installed in the room gives off 250 heat units so the cold material is taking as much heat as

$$\frac{24000}{250} = 96 \text{ sq. ft. of radiation.}$$

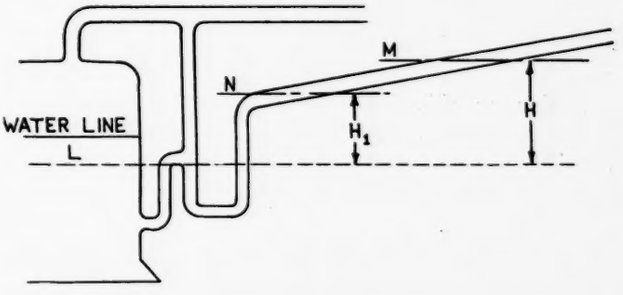
can furnish. To keep the store warm it will have to have 96 sq. ft. of additional radiation installed to take care of the heat absorbed by the material.

QUESTION 13. In dripping from a 3 in. main to a 1¼ in. drip may a 3 in. x 3 in. x 1¼ in. tee be used or would it be better to use a full size tee and reduce later to the 1¼ in.?

ANSWER. The latter method is the better of the two. With the small opening in the tee reducer much of the water is apt to flow by the drip.

QUESTION 14. Is it not supposed that a Hartford connection will keep the water from leaving the boiler? H. H. S.

ANSWER. There is, I believe, a rather widespread belief that this is the case but it is a false feeling of security. In the accompanying drawing let us suppose that the pressure loss in the system is such that with the reduced pressure in the return the water in the returns must reach the level M, of height H, before it can force its way back to the boiler. If, at the initial firing, the boiler is fired very rapidly the boiler water



may be forced back through the return until the boiler water is lowered to the level of the Hartford connection represented by the line L. The water in the return may reach some such level as N. The drip pipe now acts as an equalizing pipe and prevents any further water from being forced back into the return. Before any water can be returned into the boiler it must build up in the returns and the water of condensation will be held in the returns until the level M is reached. Thus, the water may not be siphoned from the boiler but can be carried out as steam and, if conditions are not correct, be held back until the boiler is empty. The length of time in which this can occur is not great. In a system of 1000 sq. ft. of radiation there will be 250 lb. of steam needed per hour. A boiler for a system of this size will hold about 75 gal. or 825 lb. of water so you will note that there is a complete turnover in approximately 3 hr. of time.

News of the Month

Smoke Prevention Experts Urged to Eliminate Solids in Flue Gases

At the 25th annual convention of the Smoke Prevention Association of the United States, held at the Pantlind Hotel, Grand Rapids, June 30-July 3, the members were urged by H. W. Evans to forget the problem of smoke prevention and concentrate on the elimination of the solids and sulphur gases. Mr. Evans claimed that the latter causes are doing the damage to property and linens and by getting rid of them the smoke problem also will be solved. Provisions in a smoke ordinance calling for the removal of 75% of the solids and gases will solve the entire problem, Mr. Evans stated.

It was felt at the convention that great progress has been made in smoke reduction. One forward movement presented for consideration of the association was a table recommending setting heights for heating boilers equipped with mechanical stokers. The table was prepared by the engineering committee of the Midwest Stoker Association and was presented by the committee chairman, E. L. Beckwith.

Action on this table was taken under advisement by the Public Service Committee of the association augmented by Messrs. Beckwith and Walters of the Midwest Stoker Association and a number of smoke commissioners and representatives of boiler manufacturers. Divergence of opinion prevented an immediate decision, so that the matter was left to the study of the various city departments having membership in the association.

O. W. Kastens, of the Consumers Power Company, reviewed the past and present status of district heating, summarized district heating statistics, described some of the leading plants and discussed the economics of this type of heating service.

G. D. Holliday, of the Grand Rapids Gas Company, presented data on coke and its use as a domestic fuel in relation to the smoke abatement problem.

V. W. Cherven, of the Holland Furnace Company, stated that 80% of all complaints are caused by an inadequate or leaky chimney and described methods of detecting chimney leaks. He recommended the use of a power suction machine to keep boilers clean and outlined firing methods covering anthracite, bituminous coal and coke.

Records of activities of the Committee of Ten were discussed by Oliver J. Grimes, managing director of the Committee of Ten of the coal and heating industries. Mr. Grimes suggested similar organizations in other communities to aid the public in its heating difficulties which for the most part, he said, are smoke problems caused by faulty combustion.

W. A. Carter, of the Detroit Edison Company, presented a paper on the measurement of smoke densities and soot fall. Measurement of suspended impurities was divided into two classes, those made out-of-doors and those made indoors, such as in boiler breechings. Various methods and equipment, such as smoke charts, the Umbrascope, the Bausch & Lomb smoke inspection instrument, Owens jet dust counter, and the automatic filter, and the measurement of ultra-violet radiation, were pictured and described.

James J. Fitzgerald was elected president for the coming year. Other officers are: L. G. Plant, first vice-president; Herbert H. Dunn, second vice-president; Frank A. Chambers, secretary and treasurer; George Beck, sergeant-at-arms.

Toronto, Ont., was selected as the convention city for 1932.

Motion Picture Engineers Discuss Noise and Ventilation

According to the report of the sound committee of the Society of Motion Picture Engineers, presented at their recent spring convention held in Hollywood, Calif., poor theater acoustics constitute one of the serious causes of poor sound reproduction in theaters.

H. B. Santee stated that attention

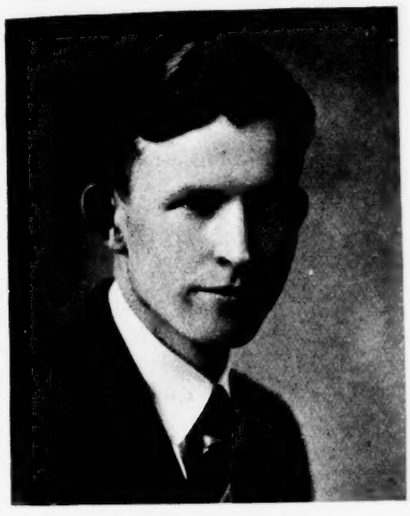
A library recently made a study of its air filters. Analysis showed that the filter oil contained 0.55% of sulphuric acid before the unit was in operation, and 1.07% after the filter was in use, indicating that the oil was absorbing acid—harmful to book bindings—from the air. This view shows a horizontal filter.

must be given to the transmission of noise from the projection room into the theater, from the ventilating system, from sources external to the auditorium and to miscellaneous noise sources within the auditorium.

Mr. Schlanger, a New York theater architect, presented a paper entitled "Reversing the Form and Inclination of the Motion Picture Theater Floor for Improvement in Vision." Mr. Schlanger's plan is to reverse the slope of the theater floor, making the floor slope upward to the screen, instead of down as is the case now.

Humphreys to Be Ahrens Professor at Carnegie

Clark M. Humphreys has been appointed assistant professor of heating, ventilating and plumbing at



Clark M. Humphreys

Carnegie Institute of Technology, Pittsburgh, effective next fall. He will be in charge of the curriculum of the Theodore Ahrens professorship.

Professor Humphreys is a graduate of Ohio State University, and since graduation has been in charge of heating, ventilating and mechanical equipment in the State Architect's Office, Columbus, Ohio.

He will be assisted by Theodore F. Rockwell, who has been appointed instructor in plumbing and heating.

Cleveland Preparing for Second International Heating and Ventilating Exposition

With over half of its exhibit space already sold, the Second International Heating and Ventilating Exposition, to be held in Cleveland, Ohio, January 25-29, 1932, in conjunction with the annual meetings of the American Society of Heating and Ventilating Engineers and the American Society of Refrigerating Engineers, is well on its way to duplicate and even surpass the success of the 1930 show in Philadelphia.

One advantage the forthcoming show will have is its central location in the Cleveland Public Auditorium Annex, which is in the heart of the Cleveland business district. Another advantage is the fact that the exhibits, particularly those containing coal, gas and oil-burning equipment, will be seen in full operation.

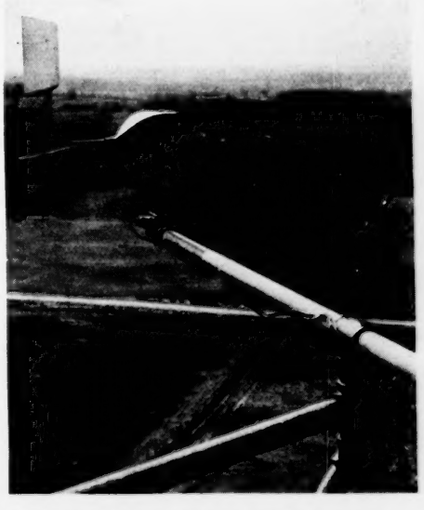
An idea of the scope of the Second International Heating and Ventilating Exposition is to be seen in the fact that it will embrace separate sections, one for the heating and ventilating industry in general, an oil burner section, a gas section, and a warm-air section. In addition to the endorsement of the American Society of Heating and Ventilating Engineers, the exposition will have the active support of the American Oil Burner Association and the American Society of Refrigerating Engineers. All three of these organizations will have booths at the show, making the exposition in fact representative of every branch of heating and ventilation.

Reports of Investigational Work Predominate at A.S.H.V.E. Summer Meeting

Mixing entertainment with technical sessions, as has become the rule at the semi-annual meetings, the Swampscott meeting of the American Society of Heating and Ventilating Engineers, June 23-26, drew an attendance greater than anticipated, the enrollment being in the vicinity of 300. Many enjoyed the trips, excursions, golf tournaments and banquet arranged as a part of the formal program, while others took advantage of the bathing beaches and fine motor drives in the neighborhood.

The three technical sessions on Tuesday, Wednesday and Thursday were crowded with papers[1] and discussions, and with the reports of the standing and special committees. The program included a total of 12 technical papers, while 20 items were covered, including the program formalities and committee reports. The lively discussions which took place reflected the interest shown in the papers, and in several cases brought out differences of opinion on disputable points.

The predominant position of investigational work was clearly shown by the fact that nearly all of the technical papers were based on the results of such study. Only one paper was of the kind which could be classified as a discussion of policy or of ways and means rather than reporting the results of an investigation. A notable point in connection with the sources of the papers was that one of them reported studies made under the direction of a utility organization, while two were made in private laboratories of commercial organizations entirely apart from the organized research activities of the society itself. Four of the papers were from projects carried on cooperatively at universities, and one was



Anemometer which records change in wind pressure in one-tenth second.

A new type anemometer developed by the Department of Engineering Research, University of Michigan, for the National Electric Light Association to determine the intensity, duration and extent of wind gusts. With this instrument it is possible to record a change in wind pressure so rapidly that within one-tenth of a second all trace of the first impulse has disappeared. Twelve of these instruments are used simultaneously in a field, seven being mounted on poles 50 ft. high to obtain a horizontal section of the gusts, and five on a tower 250 ft. high to obtain a vertical section.

[1] *Some of these papers are abstracted on pages 71 to 73 of this issue of Heating and Ventilating.*

the result of work at the society laboratory.

The report of a committee for drawing up a set of rules of procedure for rating and testing concealed gravity-type radiators was in the form of a proposed code presented for the consideration of the meeting. It represented the proposals as drawn up by the committee following its earlier report at the January meeting, and included a revision of details as well as a rearrangement of the apparatus to be used when hot water is the heating medium. The proposals brought forth many suggestions as to details. Action adopting the proposals was not taken.

The committee on ventilation standards presented a report of a rather informal nature in that printed copies were not distributed. It appeared from the wording of the report as read that the final draft will include a statement of the ends to be sought and the quantities of air to be handled. As nearly as could be judged by one attending the meeting the final draft of the report is still far from complete.

The report of the laboratory as compiled and presented by Director Houghten listed eleven projects now in progress as follows:

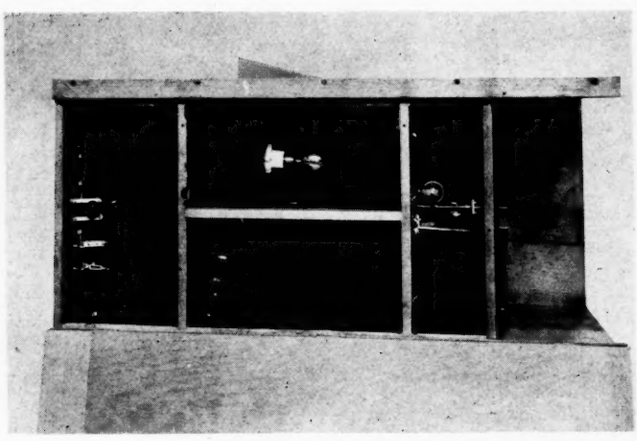
1. Heat transmission
   (a) Through walls by the hot-box method (University of Minnesota).
   (b) Film conductance co-efficient determinations (University of Minnesota).
   (c) Conductivity of concrete (Laboratory).
   (d) Solar radiation studies (Laboratory).
2. Ventilation of garage and bus terminals (Washington University, St. Louis).
3. Pipe and tubing (sizes) carrying low pressure steam or hot water.
   (a) Pipe capacities for steam heating (Laboratory).
   (b) Pipe capacities for water heating (Texas A. & M.).
   (c) Heat emission (Laboratory).
4. Atmospheric dust and air cleaning devices (Washington University, St. Louis).
5. Radiation (University of Illinois).
6. Infiltration in buildings (University of Wisconsin).
7. Measurement of air flow through registers and grilles (Armour Tech.).
8. Air conditions and their relation to living comfort.
   (a) Atmospheric characteristics (Harvard).
   (b) Heat interchange (Laboratory).
9. Oil and gas-burning devices.
   (a) Oil study (Yale).
10. Sound in relation to heating and ventilation (Plans tentative).
11. Correlating thermal research (A committee undertaking cataloging and filing of information).

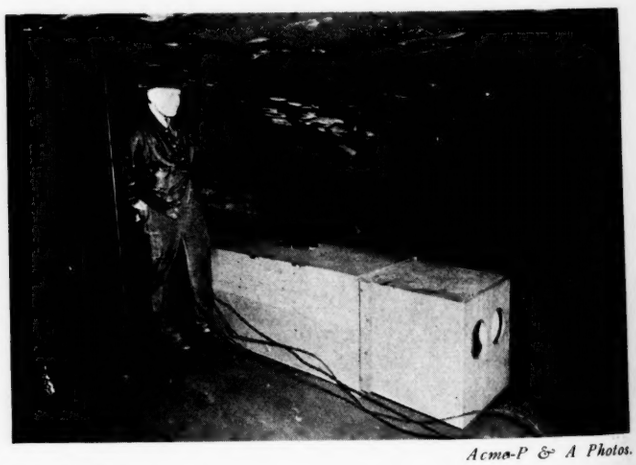
Appointment of Professor A. C. Willard as technical adviser to the research committee was announced by the chairman of the committee. The chairman also stressed the fact that the committee is formulating its plans and that it desires information and suggestions from the membership.

The paper by Prof. Rowley entitled "Essential Elements for Determining Heating Plant Requirements" called attention to the several factors which affect the problem. He noted both their importance and the lack of information concerning their elements. He felt that the time had arrived when definite recognition should be given to the heat capacity of walls and for study to be given to the variations in weather conditions.

After the years of effort which have been given to studies to arrive at suitable and reliable figures for use in design there is no use attempting to dodge the conclusion that the factors now in use leave much to be desired. This same conclusion has been reached by other authors who have presented their views both in society papers and elsewhere.

"Steam Condensation an Inverse Index of Heating Effect," presented by Prof. A. P. Kratz and M. K. Fahnestock showed that when air temperature at the 30 in. level in the testing room used by them is kept constant at 68,° the smaller the condensation the greater the heating effect. From this the conclusion is reached that for the direct





Acme-P & A Photos.

Electric Eye Charts Deadly Fumes

The so-called electric eye, used in the Holland Tunnel, through the medium of photo-electric cell, records the presence of carbon monoxide and other gases and dust in the atmosphere. (Left) The visibility meter, showing the light source, photo-electric tube and amplifying equipment. (Right) Measuring the conditions in the exhaust duct of the tunnel, above the traffic lanes.

radiators tested the condensation is an inverse index of the heating effect.

Neither the paper nor the discussion which followed brought out clearly the tendency indicated by the test data. As the condensation decreased the temperature differential from floor to ceiling also decreased. Carrying this tendency to its logical conclusion would indicate that minimum condensation can be expected when the temperature differential from floor to ceiling is a minimum. In other words minimum heat would be used to warm a room when the air temperatures in all parts are uniform. Just how generally true this tendency would be is a point on which there is no existing evidence. Several experimenters and some inventors have aimed at this condition and some have argued as to its logical basis but direct experimental evidence is lacking. The tests reported in the paper point strongly toward the reasonableness of such a conclusion at least in so far as direct radiator methods are concerned.

Pennsy Equips Air Cooled Diner

The Pennsylvania Railroad has recently placed in service its latest type dining car equipped with an air cooling system which will maintain a temperature inside at least 12° below the outside temperature. Acoustically treated insulation is used to decrease train noise and minimize the heat transfer.

The air cooling system consists of an ice chamber under the car, cooling radiators, through which ice cooled water from the chamber is circulated, and blowers for circulating cooled air through the radiator coils into the car.

The outer windows of the car are permanently sealed, the passageway doors preventing the entrance of heat through the outer doors and halls as diners enter and leave the car.

Decorations are in gray tones, with blue trimmings, with metal decorations in silver.

Birmingham Gets New House-Heating Rates

A new schedule of gas house-heating rates was ordered recently by the Public Service Commission for customers of the Birmingham (Ala.) Gas Company. The new rate provides for a 20% reduction from the old rates.

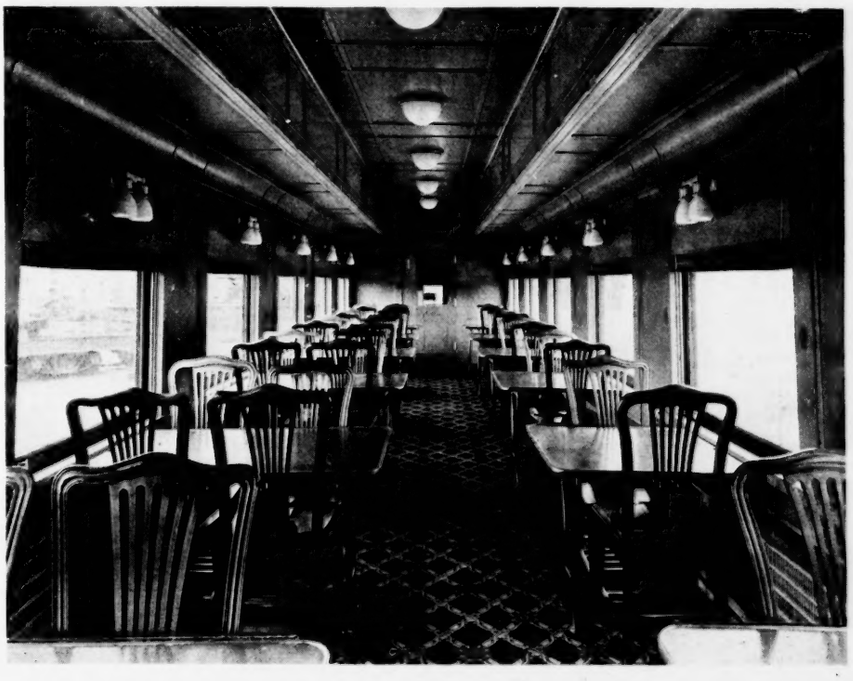
The commodity charge was cut from 40 to 35 cents per 1000 cu. ft. for the first 40,000 cu. ft., and from 35 to 30 cents for each additional 1000 cu. ft. The capacity rate was reduced from six to three cents per square foot of radiation.

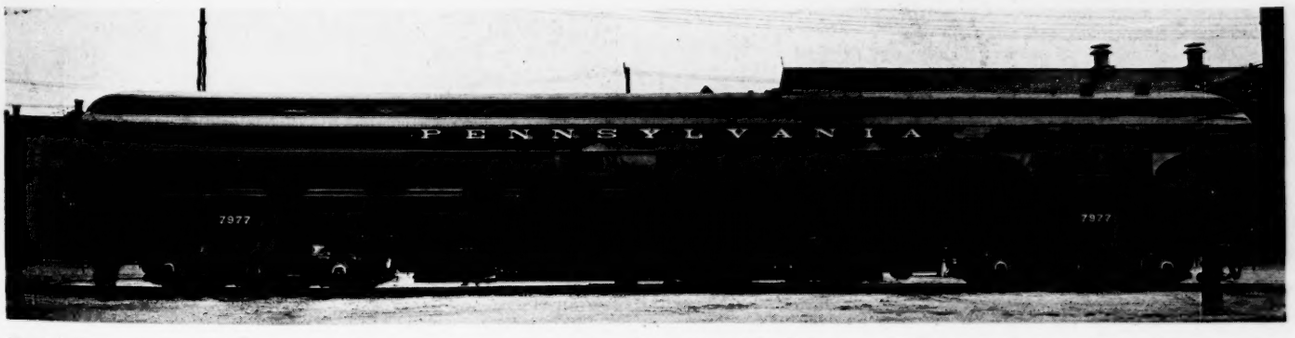
News of the Month

British Engineers to Build "Controlled Weather House"

At the summer meeting of the Institution of Heating and Ventilating Engineers (Great Britain), held at Harrogate, June 22-24, it was proposed to construct a Controlled Weather House at the Building Research Station. The walls, floors and ceilings of an experimental room would be exposed to controlled conditions by enclosing the room within a larger structure, the temperature of whose walls can be artificially maintained.

With such an installation a study and comparison of different types of heating systems will be greatly expedited. The council has appealed to members of the institution and to the heating and ventilating industry





The bottom view shows the exterior of the new Pennsylvania ice-cooled dining car. The upper view shows the gray and blue interior.

in Great Britain for such contributions as will be necessary to carry out the undertaking. This work will be an extension of the work of the Department of Scientific and Industrial Research, whose work on heating and ventilating has been confined largely to heating and ventilation of industrial buildings.

Reports presented to the standing advisory committee include those on heat transmission coefficients; the eupatheostat, an instrument for regulating the heating of a room; the warming of walls; solar radiation; flow of air through a wall; measurement of heat flow; microvolt-hour meter for integrating the flow of heat through a window; the reflecting powers of rough surfaces; the heating of school buildings, and a precision sunshine recorder.

A. F. Dufton presented a paper on radiant heat. In his paper Mr. Dufton stated that:

"The temperature of an environment with air and walls at different degrees is not easily specified. From the point of view of comfort it is the rate at which heat is lost from the body which seems to be important. The effective temperature of an environment has therefore been provisionally defined as that temperature of a uniform enclosure in which, in still air, a sizeable black body at 75°F. would lose heat at the same rate as in the environment. It should, perhaps, be emphasized that this scale of effective temperature does not extend above 75°.

This scale of effective temperature differs from the American psychrometric scale, which is an experimentally determined index of a person's feeling of warmth in air of known temperature, humidity and velocity. The American scale, which takes humidity into account while ignoring the effects of radiation, finds its main application in the maintenance of comfortable conditions indoors in summer."

The annual banquet was held June 23. In the evening President and Mrs. Sam Fox received the members in the drawing room of the Hotel Majestic.

Hildreth Elected President of Philadelphia Anthracite Club

Approximately 100 representatives from the heating equipment and anthracite industries on June 8 officially organized and named the Anthracite Club of Philadelphia.

Prominent among the organizers are: W. P. Mackenzie, Motor Stoker Corporation; D. E. Welch and E. G. Raymond, United States Radiator Corporation and Pacific Steel Boiler Company; F. C. Hibbs, H. B. Smith Company; M. G. Bittell, Chew Bittell Company; C. T. Moyer and N. J. Roys, Richardson & Boynton Company; Vernon B. Bickmore, Starr & Bickmore; Arnold Michelson, Minneapolis-Honeywell Regulator Company, and Edgar N. Black, Kewanee Boiler Company.

Following the adoption of a set of by-laws at the organization meeting, Lane W. Hildreth of the Anthracite Service was elected president.

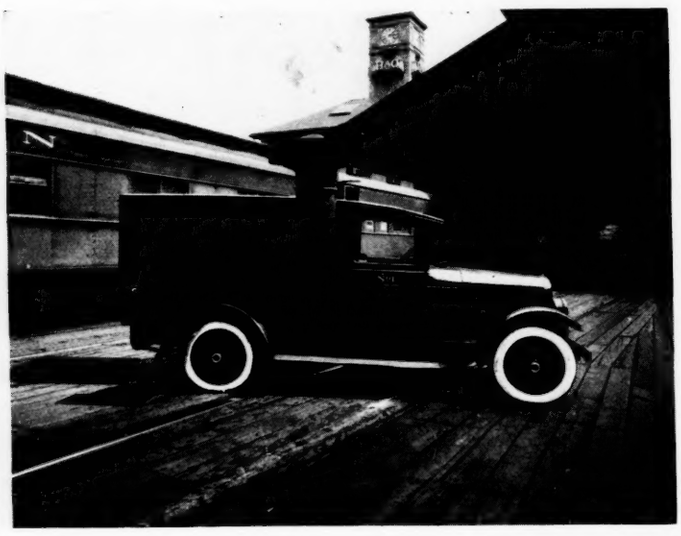
June Weather

June, 1931, was a warm month in the middle west, particularly so at Chicago and St. Louis. Emphasis is further stressed on the temperatures, at both of these cities during the latter half of the month, the first 17 days having averaged about normal. St. Louis had 22 days with maximum temperature 85°, or higher; 13 consecutive days with 90°, or higher, and 6 consecutive days with 100°, or higher, three of these being at 102°. At Chicago there were 13 days with the thermometer at 85°, or higher; and 7 days with it at 90°, or higher. For the month the average was 4.3° above normal at Chicago, and 4.6° at St. Louis.

These same conditions continued over the Fourth of July with highest temperature 104° at St. Louis and 98° at Chicago.

New Dust Eliminator Tested in New York

A test of a new suction dust eliminator, devised to protect workmen from silicosis, the deadly lung disease which affects operators in rock drilling, sand blasting, and metal crushing, was made in New York,



Pre-cooling sleeping cars on the B. & O.

Engineers of the Baltimore & Ohio Railroad have developed the truck and apparatus shown above for pre-cooling sleeping cars fo night runs. A large fan draws the outside air across ice cakes and discharges it into the car through a window in the passageway thus lowering the temperature in the car. Warm air passes out through overhead ventilators. The system is used in Baltimor Pittsburgh, Chicago, Washington, Jersey City and Akron.

June 15. The test was made in the presence of a committee of engineers, health and safety experts, contractors and labor representatives, appointed by Miss Frances Perkins, State Industrial Commissioner.

The dust eliminator has a metal hood through which the drill passes. The air sucks the dust, resulting from the bite of the drill, into a pipe, where it is taken into specially constructed metal reservoirs, where the heavier particles are separated from the fine dust by means of air currents. Finally it is all settled by means of water sprays and is washed away with the water. The machine not only is a protection to the health of the drillers, but is also a measure of economy in building operations, as it permits the drills to be operated at full power and high efficiencies. It also keeps particles of rock and dust from the drills from going into the air to be deposited in offices and homes in adjoining districts.

A. W. Clark Heads Oil Burner Dealer Division

Appointment of Arthur W. Clark as managing secretary of the newly-created dealer division of the American Oil Burner Association was announced by Lionel L. Jacobs, chairman of the board of governors of the dealer division, at a recent meeting of association directors at Toronto. Mr. Clark, former vice-president of the Wayne Home Equipment Co., Fort Wayne, Ind., has already assumed his duties.

Government Needs Heating Engineers

The United States Civil Service Commission has announced open competitive examinations for an associate engineer in heating and ventilating, and an assistant engineer in heating and ventilating. Applications must be on file with the United States Civil Service Commission, Washington, D. C., not later than August 21. The examination is to fill vacancies for duty in Washington, D. C., or in the field.

The entrance salary for the associate engineer will be between $3200 and $3800 per year, and for the assistant engineer from $2600 to $3200 per year. Competitors will not be required to report for examination at any place, but will be rated on their education, training and experience. Applicants must have completed at least two full years of an acceptable engineering course. Certain specified additional education or experience are required. Full information can be obtained from the Secretary of the United States Civil Service Board of Examiners at the post office or customhouse in any city, or from the United States Civil Service Commission, Washington, D. C.

New Building Code Issued by Underwriters

The National Board of Fire Underwriters recently issued the fifth edition of its building code, providing for regulations governing the construction, alteration, and equipment of buildings.

Section 505, article V, covering light and ventilation, mentions mechanical ventilation as follows: (a) When mechanical ventilation is required, or is permitted as an alternative, the system shall be designed and constructed in accordance with generally accepted good practice, to provide the necessary changes of air, but not less than prescribed in this section.

(b) Except as otherwise specifically prescribed by law or in duly promulgated rules, the recommendations of the American Society of Heating and Ventilating Engineers shall be deemed to be generally accepted in good practice.

The code also includes information on chimneys and flues, heat appliances and forced draft systems.

COMING EVENTS

September 7-11, 1931. Annual Convention and Mechanical Exposition of the National Association of Power Engineers. Headquarters at the Convention Hall, Kansas City, Mo. Secretary, Fred W. Raven, 417 S. Dearborn St., Chicago.

September 14-17, 1931. Sixtieth Annual Convention of the American Public Health Association, at Montreal, Canada.

October 12-13, 1931. Thirteenth Annual Convention and Exhibition of the American Gas Association, Municipal Auditorium, Atlantic City, N. J.

November 30-December 5, 1931. First National Exposition of Mechanical Handling at the Grand Central Palace, New York.

January 25-28, 1932. Joint-Annual Meeting of the American Society of Heating and Ventilating Engineers, and the American Society of Refrigerating Engineers, at Cleveland Ohio

January 25-28, 1932. Second International Heating and Ventilating Exposition, at Cleveland, Ohio.

April, 1932. Ninth Annual Convention and Oil Burner Show of the American Oil Burner Association, Boston, Mass.

Clyde Jennings

Clyde Jennings, former editor of the "Sanitary and Heating Age" died of heart disease on Friday, June 7, at the home of his son in Philadelphia. He was 55 years old.

Robert W. Pryor

Robert W. Pryor, of the firm of Koithan and Pryor, 39 Cortlandt St., New York, died at his home in Newark, July 10, after a six months illness.

Following his graduation from Stevens Institute of Technology in 1902, Mr. Pryor accepted a position with the Buffalo Forge Company and after a period of training was assigned to the New York branch office.

In 1909 he joined in forming the partnership of Koithan and Pryor, as sales engineers and representatives of the Buffalo Forge Company, the Carrier Air Conditioning Company and the Buffalo Pump Company. The partnership continued uninterruptedly until Mr. Pryor's death.

He was a member of the Essex Fells Country Club, Dotac Athletic Club, Engineers Club, American Society of Mechanical Engineers, American Society of Heating and Ventilating Engineers, and Tau Beta Pi.

He is survived by his wife, a daughter and two brothers.

Correspondence

Favors Low Oil-Fired Boiler Ratings

EDITOR HEATING AND VENTILATING:

The writer is of the opinion that serious consideration should be given to the common practice of giving heating boilers higher rating when operating with oil than when operating with coal.

It is undoubtedly true that you can "get away with" a smaller boiler, but is it good engineering practice?

There is at least one manufacturer who is doing a good business with a so-called economizer and another who promises greater savings if his combination boiler and oil burner is installed. This manufacturer gives the square feet of heating surface in his boiler and when you check it up you find that he is operating at less than 70% of rating on a horsepower basis instead of over-rating which accounts for the very low flue gas temperatures which he gets.

The economizer referred to really acts as an extension to the boiler and the writer knows of at least one case where the flue gases were so hot that they set fire to the chimney and after the installation of an economizer, conditions were very much improved.

It is not unusual to find that when a boiler is changed from coal to oil the flue gas temperature goes up beyond the point required for reasonable economy and safety. It is, of course, a good selling point to talk about how quickly the boiler control responds to temperature changes but complaint is often made that the boiler operation is too sensitive for the system. If the system is slow in equalizing and the boiler responds very quickly to a thermostat placed in one room, it does not give the radiators time to equalize the temperature in the other rooms.

In one case where the head room in the cellar of a residence is low and a vapor system is installed which operated quite satisfactorily with coal, there has been trouble since an oil burner was installed due to flooding of the mains and holding up the condensation in the radiators owing to the fact that the pressure in the boiler builds up so quickly that there is too much difference between the boiler and return pressures to be taken care of by the available head.

Of course, there are certain advantages in having a small and sensitive boiler, especially from the salesman's point of view, but experience has shown that there are some very decided disadvantages and the problem of the proper rating of oil burning boilers should be given the fullest consideration from the standpoint of safety, economy and satisfactory operation of the heating system.

J. O. G. GIBBONS

Newark, N. J.

The Degree Day as an Estimating Unit

EDITOR HEATING AND VENTILATING:

I was very glad to read your article on the degree day in the June issue of HEATING AND VENTILATING because I believe it is important to explain the objectives and limitations of this unit to the heating industry.

As one of those who has been identified closely with the development of the unit, I think it is important to call to your attention, however, that as far as the use of it for estimating gas consumption is concerned, it has been found very good. The efficiency of gas units is fairly steady over quite some variation in load, and therefore the use of the unit in gas estimating is surprisingly accurate. It is not accurate, however, as you correctly point out, if the period is too short, if an attempt is made to estimate the fuel consumptions for the months of September, October, April or May, nor is it accurate when used for southern climates of less than 3,000 degree days. It is also not usable without modification for the estimation of the fuel requirements of large buildings above 1500 sq. ft. of installed steam radiation.

Although not yet published, I have been working for some time on data which will modify the unit for the conditions for which it is not now usable, and I should be very glad to send you the results of my findings when they are ready.

Another important variable which you have not brought out in your article is the effect of individual living conditions. To illustrate this, I have in mind a pair of homes in Jersey in which it so happens that the owner of one sold his house to the owner of the other, and both families exchanged homes. Both were gas heated, and both were thoroughly insulated homes. Nevertheless the fuel consumption after making this change was most surprising, because the consumption in the one house went down about 30 per cent and the consumption in the other home nearly doubled. This was undoubtedly due to the fact that one family was given to a good deal of late entertaining and the other family was quite conservative. Moreover, although thermostats are set at 70°, there are many families who demand 75° or more inside temperature.

I will also call your attention again to my article in the December HEATING AND VENTILATING, in which I proposed an extension to the industrial degree day system for the estimation of the gas requirements of industrial buildings. These data seem to be working out very nicely.

C. GEORGE SEGELEN

Industrial Engineer,
American Gas Association,
New York.

Degree Days for New York

EDITOR HEATING AND VENTILATING

Can you give me the number of degree days, by months, for New York for the heating season ending June, 1931. L. S.

Brooklyn, N. Y.

September, 1930	12
October	317
November	576
December	929
January, 1931	982
February	869
March	758
April	434
May	201
June	24
Total	5102

New Equipment

Bishop & Babcock No. 12 Unit Heater

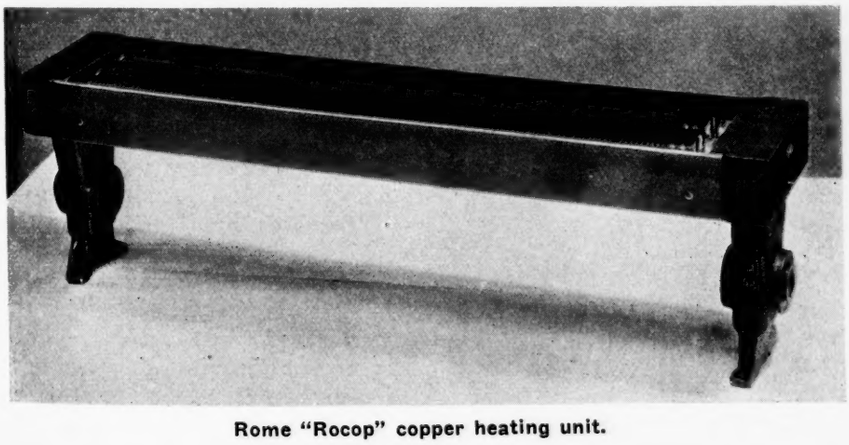
The Bishop and Babcock Sales Co., 4901 Hamilton Ave. N. E., Cleveland, Ohio, announces the No. 12 unit heater, especially designed for small installations in one-story buildings, such as gasoline stations, groceries, garages, etc. The heater can be located near the ceiling so that the condensation can return by gravity to a boiler set on the floor. The unit is equipped for variable speed operation. The top speed is so regulated as to provide a high rate of air change at maximum heating capacity, although medium speed is recommended for normal conditions. Mild weather conditions are met with the use of the low speed.

Temperature control is obtainable by the use of a thermostat. The motor permits starting at low, medium or high speed with no possibility of stalling at intermediate speeds.

The unit has a capacity of 109 sq. ft. of radiation at low speed and 163 sq. ft. at high speed, air temperature of 60° and 2 lb. steam pressure.

Rocop Concealed Radiator

Rome Radiation Co., Division of Revere Copper and Brass Inc., 230 Park Ave., New York, has developed a concealed heating unit known as Rocop. The new unit employs copper as the heating unit, the heating medium being contained in seamless copper tubing and the surface consisting of reinforced copper. The headers, cast from special high test iron, are assembled to the heating element by means of compression screws with built-in dirt pockets. Surfaces are metallicly bonded. The unit is offered in a range of sizes designed to meet all standard building conditions.

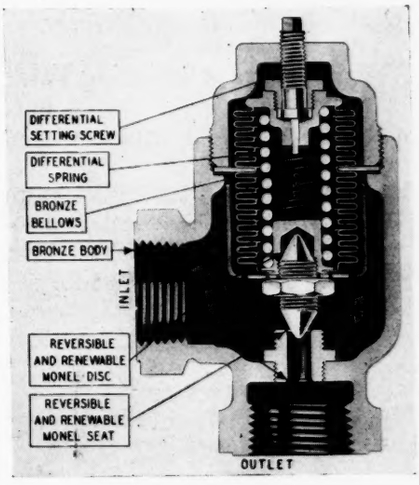


Rome "Rocop" copper heating unit.

Tag Steam Trap

C. J. Tagliabue Mfg. Co., Park and Nostrand Aves., Brooklyn, N. Y., is offering to industrial users a steam trap under a 30-day free trial policy.

A differential setting feature



Tagliabue trap.

makes it possible for the trap to discharge condensate at a temperature corresponding to a uniform differential pressure from zero to 20 lb. below the operating steam pressure. If the trap is set to discharge condensate at a temperature corresponding to as much as 20 lb. less than the operating steam pressure, it will discharge the condensate at this differential regardless of whether the steam pressure is 50 or 125 lb., without further adjustment of the differential setting.

When the differential setting screw is all the way up on the trap, there is no tension on the spring and the trap will discharge condensate from 1° to 2° below the temperature of the operating steam. When tension is applied, by turning down the setting screw, a pressure is created on the inside of the bronze bellows which aids the vapor pressure developed in the bellows to close the valve.

The trap is available in one inch size only, as the 5/16 in. valve opening assures ample capacity on every steam line.

Automatic Air Control for Domestic Stokers

A device for controlling the air supply to domestic stokers has been developed by The Will-Burt Co., Orrville, Ohio. The device is installed in the blast pipe of the stoker and automatically regulates the amount of air entering the furnace.

The working parts consist of a butterfly valve attached to its shaft off center a sufficient amount to compensate for the difference in blast stream to give it perfect balance. A target is attached to its shaft at the top and the target plate is provided with an opening to pass the same amount of air at which an ordinary damper would be set for the maximum fuel bed.

The target and butterfly valve are connected with suitable cranks and connecting rod. On the butterfly valve connection is attached a rod and small weight for properly adjusting the position of the damper. When the adjustment is made properly for the average fuel bed, the target hangs in a vertical position. If the fire becomes thin the increased velocity of air raises the target and partially closes the butterfly valve, thus reducing the air supply. When starting a fresh fire in the furnace, the outfit admits only sufficient air to properly blow the fire.

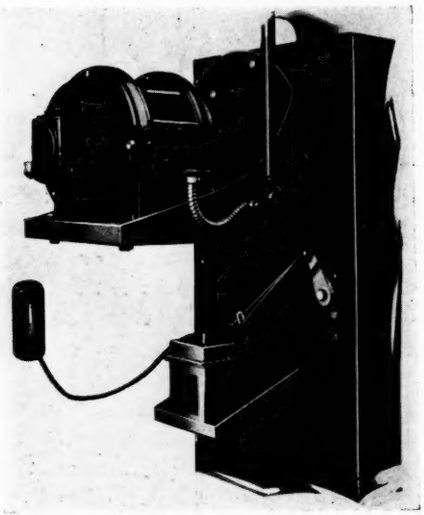
June-Aire Furnace

American Foundry & Furnace Co., Bloomington, Ill., has announced a new model of the June-Aire gas-fired warm-air furnace. The unit is in one, two, three or four

sections, with a capacity output of 72,000 B.t.u. per section per hr. Each section has a multiblade centrifugal blower mounted on a common shaft with the blowers for the other sections. The unit is equipped with a filter and humidifier.

Buffalo Forge Electric By-Pass Damper Control for Unit Heater

The Buffalo Forge Co., Buffalo, N. Y., is equipping the line of Buffalo Highboy and Lowboy unit heat-



Electric by-pass damper control.

ers with an electric by-pass damper control designed to maintain an outlet temperature at the unit heater which will be the minimum possible to take care of the heat losses in the building.

The mechanism consists of a compact motor operated damper controller actuated by room thermostats, current from the main circuit being furnished to the damper controller through a small transformer. The controller actuates through interlocked dampers which allow recirculated air to enter above the heater element, providing automatic temperature control of the leaving air temperature. The complete mechanism is self-contained with each unit heater.

The damper controller mechanism is interchangeable end for end. The opening for recirculated air can either be at the front or the back side of the unit. Recirculated air is drawn from the front when it is desired to return air from the room. The opening is placed at the back when it is desired to furnish outside air.

Autovent 31 Series Propeller Fans

Autovent Fan and Blower Co., 1805 N. Kostner Ave., Chicago, Ill., announces the 31 series line of propeller fans, the outstanding features of which are non-overloading fan wheels, a complete range of sizes, and elimination of motor burn-outs. The smaller sizes have wheels of six blades; the larger sizes, eight blade wheels.

The fans are available in 12 sizes for either direct current, single phase or multiphase alternating current, with capacities ranging from 1400 to 13,000 c.f.m., free delivery.

Thrush Pressure Reducing Valve

H. A. Thrush & Co., Peru, Ind., has placed on the market a ¾ in. pressure reducing valve which will control city main pressures up to 200 lb., and may be adjusted to reduce pressure and maintain it from 150 lb. down. It is designed for use with household water systems. Working parts are made of cast brass.

Taylor Pipe Fittings for Welding

Taylor Forge & Pipe Works, P. O. Box 485, Chicago, has developed a complete line of seamless steel pipe fittings for welding consisting of elbows, tees, reducing tees, bull plugs, and reducing nipples. All sizes up to 24 in. will be ready for distribution within the near future, but at the present sizes 12 in. and smaller are available. The tees are made in sizes 2 in. to 8 in.

The fittings permit pipe systems fabricated by welding to be installed with only the use of true circumferential welds. They are lighter in weight than cast steel fittings, require less space in erection, and permit easy and economical insulation.

Taylor pipe fittings for welding.

Elbows are made without thinning or buckling of the walls of the standard center to end measurement of American standard extra heavy screwed fittings, and with end to center to end dimension equal to one and one-half times the nominal pipe diameter. The ends are machine tool bevelled.

Spence Regulators

The Spence Engineering Co., Inc., 110 East 42nd St., New York, is marketing a line of regulators, built in sizes from ¼ in. to 12 in. inclusive, for use with air, steam, water, oil, and various gases and for initial pressures up to 400 lb. and temperatures of 750°F.

The devices are self-contained units suitable for any pressure above 1 lb. and for any pressure differential greater than 1 lb.

The line includes the type ED pressure regulator for regulating a steady or varying initial pressure to maintain a constant delivery pressure and is especially applicable to heating systems. The type EP pump governor maintains a constant discharge temperature from a steam driven pump and can be used in connection with boiler feed pumps. The type EM solenoid operated valve is designed for service where a valve must be opened or closed by an electric circuit.

Audiffren Airectifier for Air Cooling

Audiffren Refrigerating Machine Co., 285 Madison Ave., New York, has developed the Airectifier for cooling air without raising the humidity to saturation.

According to A. D. Karr, the company's chief engineer, air conditioning for comfort, which involves under summer conditions cooling and dehumidfying of the air supplied to a room where people are gathered, was originally developed on two basic considerations: (1) air passing through an air washer for dehumidification and cooling must be saturated when leaving the washer; (2) this air, cooled to saturation temperature corresponding to the desired dew point of the air to be supplied, must be warmed

to a proper temperature for introduction into the room.

Until the by-pass system, which is now so widely known and used, had been evolved, it was impossible to meet the two stated requirements without using excessive quantities of refrigerating effect and much reheat.

The Airectifier method of air conditioning accomplishes the same ideal economy of performance that the by-pass system made possible. However, it avoids saturation in the air washer, brings the air out of the washer at a temperature above its dew point, and delivers the air at the correct temperature and relative humidity for introduction into the room. The results are obtained solely in the washer by automatic means of control. The action depends upon continuous, stepless, variation of the volume of water supplied to the sprays, with corresponding change in size and number of drops formed. The temperature of the spray water also under control, supplies the second factor necessary for complete regulation.

The method offers the advantage of requiring all the recirculated air returned from the room to go back through the washer before again entering the room. In this way all air supplied to the room is continuously subjected to the scrubbing action of the flooded eliminator plates in the washer.

In common with all air cooling systems employing air washers, the Airectifier method is not limited in its application to any particular type or make of refrigerating plant, nor is there any limitation as to size or scope of installation which can be handled by the Airectifier system.

In the bulletin issued by the company a graphic picture of the development is given by a specific problem, worked out to avoid cooling any air down to the dew point, but rather to exhaust it all somewhere near the desired final temperature level without too high a humidity. The method worked out was arrived at by trying various sized drops in the washer until one of the proper size was found to give due cooling, from the drop surface, and not too much condensation. Results are shown for various sizes, arriving at a diameter of 1/16 in. The number of these per unit of area, volume or time is not specified; it varies with each type and size of load. The refrigerating unit in this case cools the water, with a water circulating pump and a fan to complete the system.

Gasoroil Burner

Berghoff Properties, Inc., Ft. Wayne, Ind., a subsidiary of the Wayne Oil Burner Corporation, announces the Gasoroil burner, designed to burn either or both oil and gas. The burner is sold complete as a package proposition to the consumer for $80. It can be manually controlled from the first and second floors. The burner is not intended to compete with automatic burners but to meet ruinous price competition, and can be traded in by the owner within two years for an automatic burner.

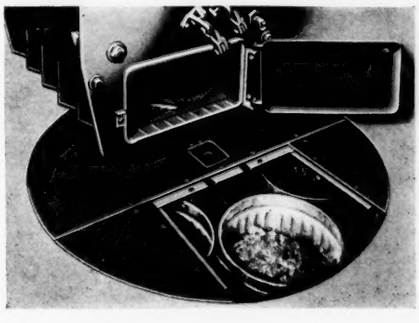
Brownell Stokers

The Brownell Co., Dayton, Ohio, announces that it has completed its line of stokers ranging from the ideal home stoker design for residence installations to the heavy duty stoker for power installations. The design includes the Brownell type A1 underfeed stoker for medium size installations in institutions and commercial buildings.

Spencer Rotary Ash Receiver

The Spencer rotary ash receiver has been developed by the Spencer Heater Co., Williamsport, Pa. The device is designed to do away with the shoveling of ashes, and to dispose of them without dust or dirt.

The ash receiver consists of a steel waterproof drum, 48 in. in diameter, containing a swivel-mounted revolving frame that holds six or eight ordinary ash cans. The necessary excavation is made and this unit placed under the boiler or furnace. An empty can is locked into position under the hole in the ashpit floor. The ashes are raked into the hole. When a can is full, a turn of a crank brings another empty can into position. After all the cans are full the ash man lifts a steel plate, removes the filled cans, disposes of the ashes, and puts the empty cans back into place. It is said that this new ash receiver is quickly and easily installed.



Spencer ash receiver.

Lewis Portable Electric Humidifier

A portable electric humidifier has been announced by Lewis Air Conditioners, Inc., Minneapolis, Minn., The evaporating unit takes the form of a float in which the heating element is enclosed. This float rides on the surface of the water in the urn. A small port hole admits sufficient water from the bottom of the float to cover the heating surface to a depth of 1/8 in. The humidifier shuts itself off.

Lewis portable humidifier.

When filled, the urn holds six quarts of water, and the unit evaporates at the rate of a pint of water per hour. The normal operating time is nine or ten hours without refilling.

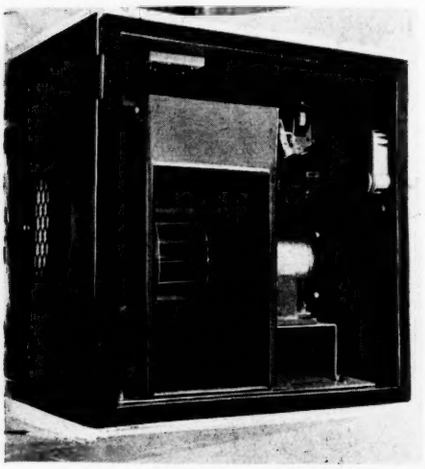
Hynes Type M Multi-Vane Electric Heater

Hynes Electric Heating Co., 240 Cherry St., Philadelphia, Pa., has announced the type M multi-vane

New Equipment

fan circulation electric heater with built-in automatic control. The unit is designed for electric heating of industrial buildings, sub-stations, garages, etc.

The heating surface is construct-



Hynes fan circulation electric heater.

ed of thin, curved metal-clad sections which form the periphery of the fan housing, permitting a large heating surface area with both sides uniformly exposed to the air streams.

In operation, cool air is drawn in through a portion of the perforated front area and passes over the motor and control panel and over the exterior surface of the heaters, forming the fan scroll enclosure. Air then travels to the fan inlet and is driven by the wheel around the interior of the heater scroll, and finally delivered at the proper temperature and velocity from the outlet portion of the front.

The unit is available in six sizes with power consumptions ranging from 1 to 30 kw., and air deliveries from 250 to 2200 c.f.m.

Silent Automatic Oil Burning Water Heater

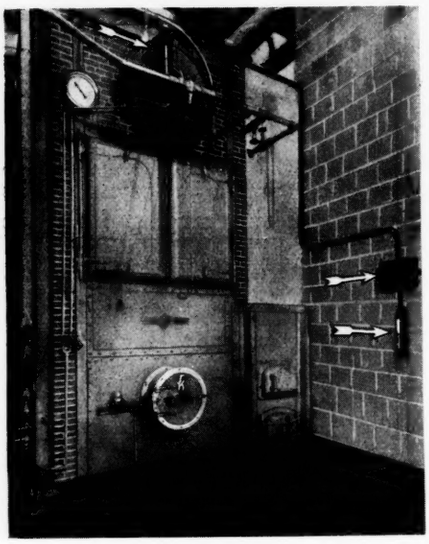
A water heater manufactured by the Silent Automatic Corp., Detroit, has been added to the company's line of automatic oil burning equipment.

The heater is available in two sizes, having storage capacities of 32 gal. and 53 gal. respectively, and heating capacities of 75 to 100 gal. per hr. at a 100° F. temperature rise. The tank itself is heavily insulated and enclosed in a steel jacket.

Water Level Televisor

Schutte & Koerting Co., 12th and Thompson Sts., Philadelphia, Pa., announces the water level Televisor, an electrical device for indicating water levels in boilers and tanks at one or more distant points. It consists of three separate units, the transmitter, distributor, and indicator.

The transmitter, attached to the boiler drum, consists of a cylindrical water chamber containing a set of electrodes which make contact with the boiler water. These electrodes, of different lengths, are connected by multiple wire cable to the dis-



S & K televisor.

tributor, which is installed on the boiler room wall. The distributor is a metal box containing a transformer and a set of relays of the magnet-coil double-pole-mercury-contact type.

The indicator is installed at eye level on the wall with a cable connection to the distributor. The indicator consists of a case in which are mounted two parallel rows of small electric lamps. These lamps are placed behind green and red glass plates and their light is reflected by a glass prism on the front of the indicator.

Spencer Gas - Combination Boiler

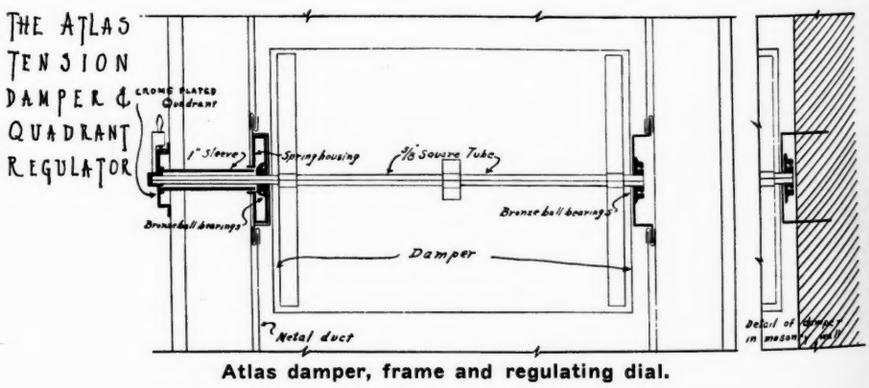
Spencer Heater Co., Williamsport, Pa., announces a gas-combination boiler, designed to meet the demand in certain sections for a coal boiler that will burn gas at certain seasons of the year. The basic design of the boiler continues along the same lines as the company's magazine feed heater, incorporating the sloping grates, storage magazine for fuel and automatic gravity feed. In addition, the boiler includes a built-in gas burner.

Among the advantages claimed for the new boiler are rapid convertibility and automatic heat with a choice of fuels. It is not necessary to change parts when changing over from one fuel to the other. The owner merely lets the coal or coke fire die out, and when he wishes a gas fire, throws an electric switch. The gas burner is always ready, as an integral part of the boiler.

Atlas Damper and Frame

The Atlas damper, frame and regulating dial is being sold by Fletcher & Co., 33 Dwight St., Springfield, Mass. The damper is said to be particularly adapted to the requirements of unit ventilator installations.

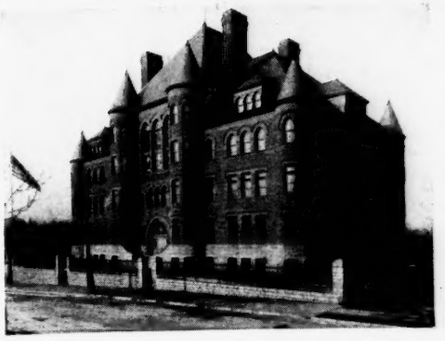
The damper works on a 5/8 in. hollow square tube, set in bronze bushings which turn in two ball races. All dampers are balanced in the factory before shipment. Heavily felted angle stops insure tightness and absence of noise. The dial and control handle are chromium plated, graduated, and marked Closed and Open.



Atlas damper, frame and regulating dial.

The *Old*
Walnut Hills
High School
Cincinnati, Ohio

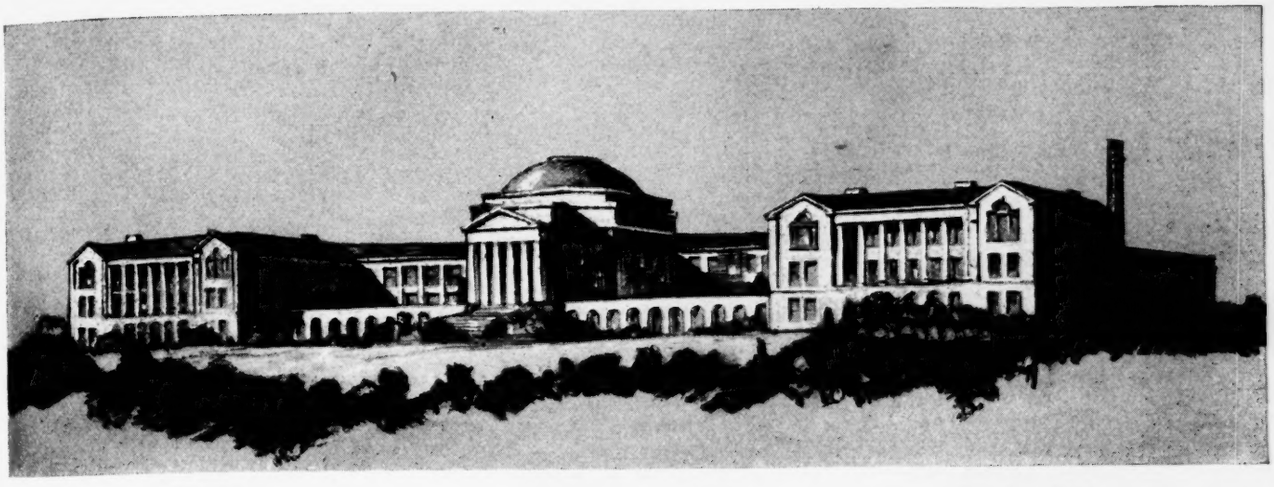
Built in
1908



23 Years of Dependable Service

rendered by Powers Temperature Control in this school was one of the reasons why Powers Regulation

was selected for the *New* WALNUT HILLS SCHOOL, Cincinnati



Architects:
GARBER & WOODWARD

Consulting Engineer:
WILLIAM E. BODENSTEIN

Heating Contractors:
THE JOHN J. VOGELPOHL CO.

After 23 years of dependable regulation in the *old* Walnut Hills High School, the Powers System of Temperature Control is still giving excellent service and will continue to do so for many more years.

Because of this and many similar records of long life and dependable service, Powers Control is being installed in the new school shown above, which is one of the largest in the State of Ohio.

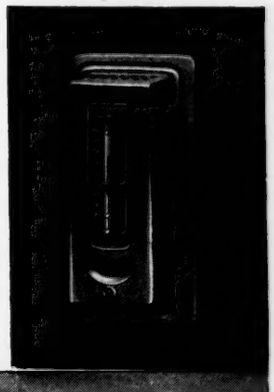
While the first cost of Powers Control is often higher; it costs much less in the end, because:

◀1▶ It often gives 15 to 20 years of Accurate and Dependable control without repairs of any kind.

◀2▶ Greater Steam Economy due to the fact that thermostats do not get out of adjustment and permit overheating.

◀3▶ Graduated Control, because of its greater accuracy, provides maximum comfort for occupants of rooms.

◀4▶ A minimum of Service Calls and the trouble and annoyance connected with them.



THE POWERS REGULATOR COMPANY

40 Years of Specialization in Temperature Control

CHICAGO: 2718 Greeview Avenue, NEW YORK CITY: 231 East 46th Street

Offices in 41 Other Cities

The Canadian Powers Regulator Company, Toronto, Ontario

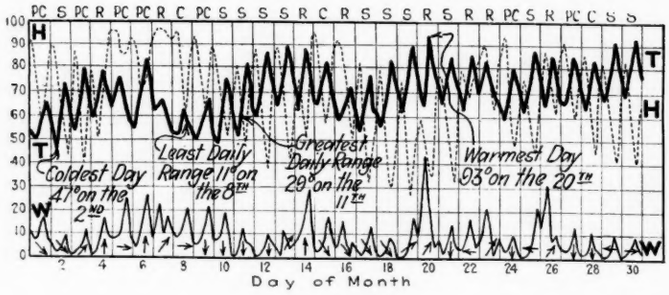
POWERS

Powers Thermostats Are Better

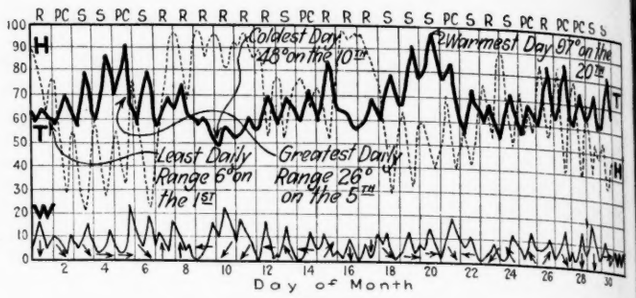
Because—they need no annual adjustments or overhauling and often give 15 to 20 years of accurate control without repairs of any kind.

The Weather

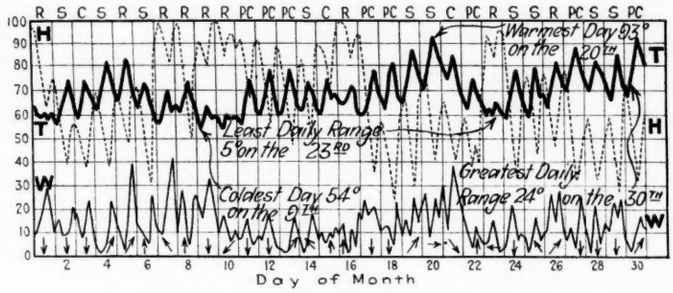
June, 1931


Coldest Day 47° on the 2ND
Least Daily Range 11° on the 8TH
Greatest Daily Range 29° on the 11TH
Warmest Day 93° on the 20TH
Day of Month

Pittsburgh

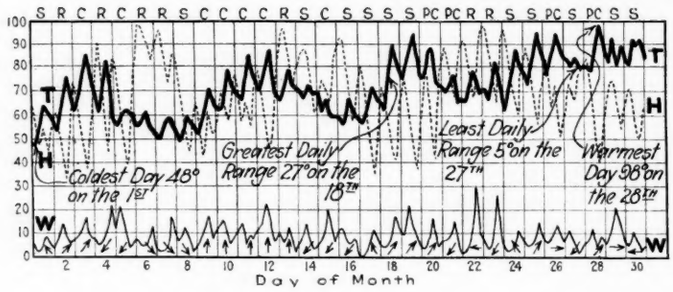

Coldest Day 48° on the 10TH
Warmest Day 97° on the 20TH
Least Daily Range 6° on the 1ST
Greatest Daily Range 26° on the 5TH
Day of Month

Boston

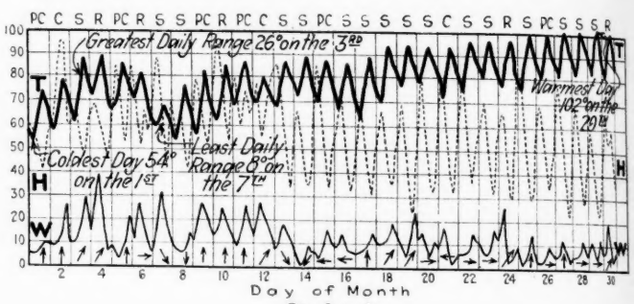

Warmest Day 93° on the 20TH
Least Daily Range 5° on the 23RD
Coldest Day 54° on the 9TH
Greatest Daily Range 24° on the 30TH
Day of Month

New York

(Hourly Observation of the Relative Humidity Plotted on this Chart)


Coldest Day 48° on the 1ST
Greatest Daily Range 27° on the 18TH
Least Daily Range 5° on the 27TH
Warmest Day 96° on the 28TH
Day of Month

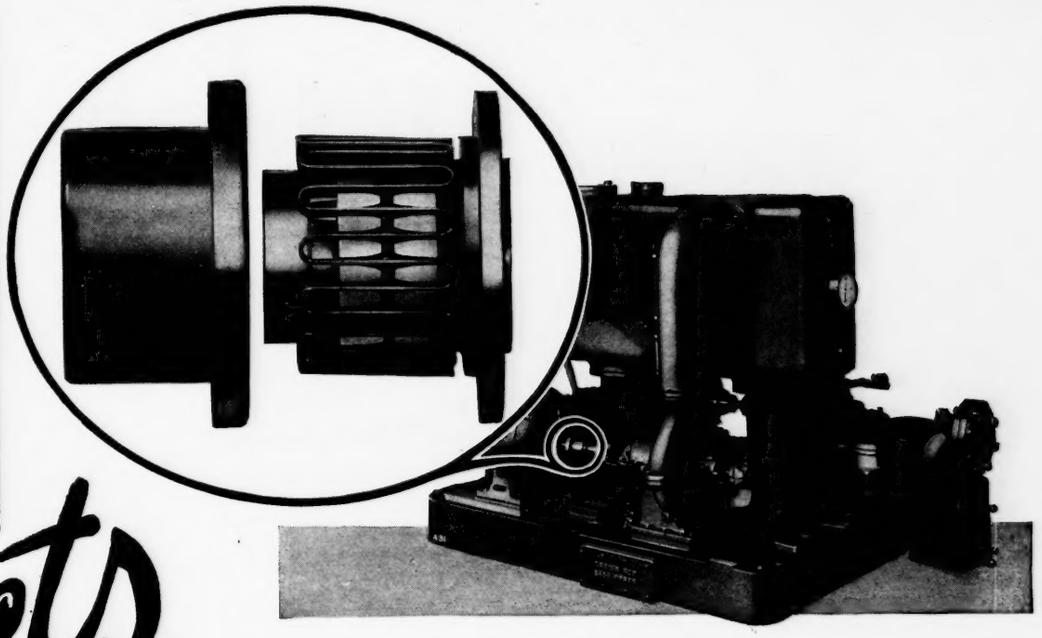
Chicago


Greatest Daily Range 26° on the 3RD
Warmest Day 102° on the 20TH
Coldest Day 54° on the 1ST
Least Daily Range 8° on the 7TH
Day of Month

St. Louis

	New York	Boston	Pittsburgh	Chicago	St. Louis
Highest temperature, deg. F.	93	97	93	98	102
Date of highest temperature	20	20	20	28	29
Lowest temperature, deg. F.	54	48	47	48	54
Date of lowest temperature	9	10	2	1	1
Greatest daily range, deg. F.	24	26	29	27	26
Date of greatest daily range	30	5	11	18	13
Least daily range, deg. F.	5	6	11	5	8
Date of least daily range	23	1	8	27	7
Mean temperature for month, deg. F.	69.4	67.2	70.	71.8	79.6
Normal mean temperature for month, deg. F.	68.8	66.4	70.7	67.3	75.0
Total precipitation, this month, inches	4.	9.13	5.72	4.78	1.98
Total snowfall, this month, inches	0	0	0	0	0
Normal precipitation, this month, inches	3.33	2.89	3.81	3.30	3.82
Total wind movement, this month, miles	8,801	4,896	4,740	5,706	7,061
Average hourly wind velocity, miles	12.2	6.8	6.6	7.9	9.8
Prevailing direction of wind	N	N.W.	N.	S.	S.
Number of clear days	9	9	7	12	16
Number of partly cloudy days	10	12	16	5	13
Number of cloudy days	11	9	7	13	1
Number of days with precipitation	11	12	10	8	6
Number of days with snowfall	None	None	None	None	None
Snow on ground, at end of month	None	None	None	None	None

Plotted from records especially compiled for HEATING AND VENTILATING by the United States Weather Bureau.
Heavy lines indicate temperatures in degrees F. Light lines indicate wind in miles per hour
Broken lines indicate humidity in percentage from readings at 8 a. m., 12 m., and 8 p. m.
S—clear, PC—partly cloudy, C—cloudy, R—rain, Sn—snow. Arrows fly with prevailing directions of wind



Facts

PREVENT SHOCKS and COSTLY REPAIRS

MOTOR AND PUMP BEARINGS OF THE AMES VACUUM HEATING PUMP ARE PROTECTED FROM SHOCKS, DUE TO SUDDEN VARIATIONS IN LOAD, BY A LUBRICATED FLEXIBLE ALL-METAL DUST-PROOF COUPLING OF SPRING TOOTH DESIGN.

ALSO, this coupling provides floating space to compensate for shaft expansion caused by varying temperature of condensate.

NOTE:—Sec. XII, Par. 25 of Am. Soc. of Heat. & Vent. Engrs. Codes—"Flexible couplings shall not be used to compensate for misalignment but only to compensate for temperature variations."

NOISE, WEAR AND FRICTION ARE ELIMINATED.
No attention is required other than the changing of grease twice a year.

Pump and motor shafts can be disconnected in a few minutes by merely moving back the coupling cover and lifting out the grid spring without moving the units.

It is this kind of good engineering practice — a regard for details — that makes "AMES" the VACUUM HEATING PUMP OF DISTINCTION.

This advertisement is the **Seventh** of the series. **Five** more will follow.

Write for Bulletin No. 522 and 532

AMES PUMP COMPANY, Inc.
30 Church Street **New York City**
DIVISION OF
AMERICAN LOCOMOTIVE COMPANY

Degree Days and Unit Fuel Consumption in Typical Cities

June, 1931

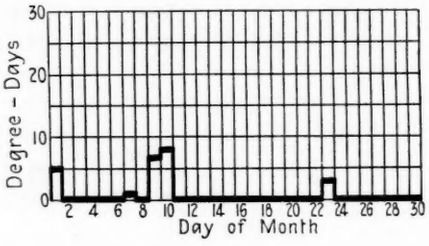
UNIT fuel consumption figures given below must be corrected for efficiency, heat content of fuel other than that listed below, for radiation emitting other than 240 B.t.u. per hr., and for radiation calculated on a basis of other than zero outside to 70° inside.

Coal is assumed as having a heat content of 12,000 B.t.u. per lb., gas, 1000 B.t.u. per cu. ft. and oil 140,000 B.t.u. per gal. To correct for other heating values, multiply the fuel consumption listed under the charts by the standard heat content just listed, and divide by the heat content of the fuel actually being used in the installation being calculated.

For radiation installed for any other outside temperature than zero, multiply the fuel consumption given under the charts by 70°, divided by the quantity (70 minus the outside temperature used).

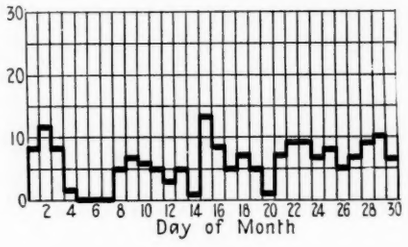
To correct for efficiency, divide the fuel consumption by the efficiency of the heating installation.

For water radiation, multiply the fuel consumption which is given for steam radiation by 5/8.



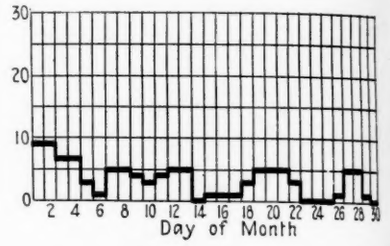
New York

Degree Days—24
Total Degree Days for Season 1930-31—5102
Lb. of Coal per Sq. Ft. of Radiation for this Month, 0.19.
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.016.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 2.30.
(See Footnote)



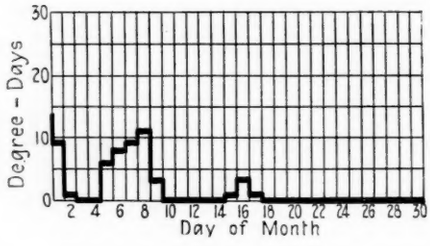
Seattle

Degree Days—179
Total Degree Days for season 1930-31—4379
Lb. of Coal per Sq. Ft. of Radiation for this Month, 1.43.
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.123.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month 17.18.
(See Footnote)



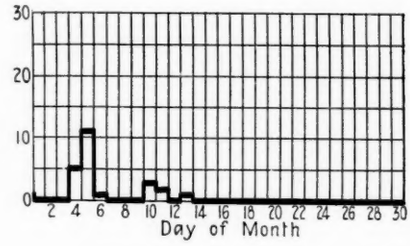
San Francisco

Degrees Days—103
Total Degree Days for Season 1930-31—2040
Lb. of Coal per Sq. Ft. of Radiation for this Month, 0.82.
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.071.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 9.89.
(See Footnote)



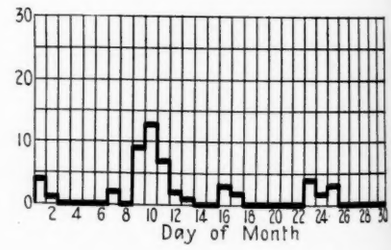
Chicago

Degree Days—52
Total Degree Days for Season 1930-31—5911
Lb. of Coal per Sq. Ft. of Radiation for this Month, 0.42.
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.036.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 4.99.
(See Footnote)



Denver

Degree Days—23
Total Degree Days for Season 1930-31—5712
Lb. of Coal per Sq. Ft. of Radiation for this Month, 0.18.
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.016.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 2.21.
(See Footnote)



Boston

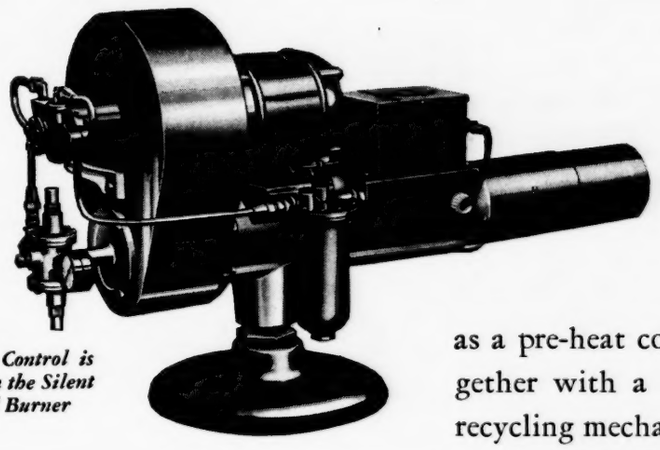
Degree Days—53
Total Degree Days for Season 1930-31—5520
Lb. of Coal per Sq. Ft. of Radiation for this Month, 0.42.
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.036.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 5.09.
(See Footnote)

Fuel consumption figures must be corrected for local conditions as explained above.

(Continued on page 92)

THERE'S ONLY

One



Penn Heat Control is available on the Silent Sioux Oil Burner

THERE's only one heat control on the market with Telechron electric timing . . . only one heat control with a combination of such features as a pre-heat coil and silver snap action contacts, together with a close differential thermostat, positive recycling mechanism and super-sensitive stack control.

Penn Heat Control!

Penn Heat Control is manufactured by the General Electric Company. It was developed in the General Electric Laboratories and has the same mechanical dependability that distinguishes all GE products.

With Penn Heat Control you have an additional, strong selling argument—*General Electric manufacture*. By equipping the burners you install with this new improved control, you assure yourself of *less* servicing and *more* satisfied customers.

Use Penn Heat Control. 20 manufacturers do, exclusively—61 use it as standard or optional equipment. If your burner comes already equipped with a control, ask your manufacturer to make it a Penn Heat Control. Increased sales and dependable operation after installation will justify your request.

STACK CONTROL

Penn Heat's stack control operates more quickly than *any other stack control*. It is extremely sensitive to all temperature changes. And because of the small angle in which contact is established, it is always fast and accurate. No mercury tubes are necessary.

RECYCLING

Some burners claiming recycling actually lack it. The automatic restoring of the control device after power failure *is not recycling*. Penn Heat Control has positive recycling—repeated starting attempts, consisting of short fuel injecting intervals, until combustion is established. The positive recycling mechanism of Penn Heat Control is the ultimate provision for safety, adding also to fuel economy.

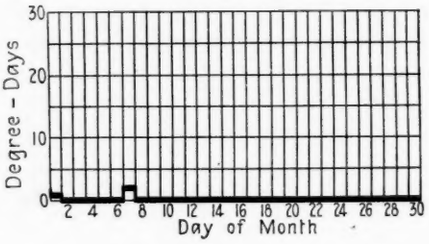
PENN HEAT CONTROL COMPANY

Franklin Trust Building **Philadelphia, Pa.**

Degree Days and Unit Fuel Consumption in Typical Cities

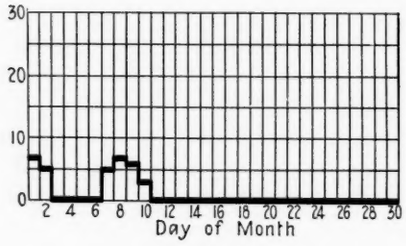
June, 1931

(*Continued from Page 90*)



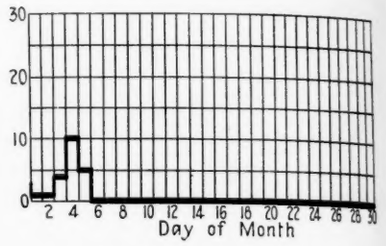
St. Louis

Degree Days—3
Total Degree Days for Season 1930-31—4415
Lb. of Coal per Sq. Ft. of Radiation for this Month, 0.02.
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.002.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 0.29.
(See Footnote, Page 90)



Pittsburgh

Degree Days—33
Total Degree Days for Season 1930-31—5480
Lb. of Coal per Sq. Ft. of Radiation for this Month, 0.26.
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.023.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this month, 3.17.
(See Footnote, Page 90)



Minneapolis

Degree Days—21
Total Degree Days for Season 1930-31—6803
Lb. of Coal per Sq. Ft. of Radiation for this Month, 0.17.
Gal. of Oil per Sq. Ft. of Radiation for this Month, 0.014.
Cu. Ft. of Gas per Sq. Ft. of Radiation for this Month, 2.02.
(See Footnote, Page 90)

	Los Angeles	Baltimore	Philadelphia	New Orleans	Atlanta	Cleveland	Cincinnati	Detroit
Degree Days	2	7	10	0	0	48	26	51
Total for Season 1930-31	665	4355	4531	1435	3428	5833	5072	6380
Lb. of Coal per Sq. Ft. of Radiation for June, 1931	0.02	0.06	0.08	—	—	0.38	0.21	0.41
Gal. of Oil per Sq. Ft. of Radiation for June, 1931	0.001	0.005	0.007	—	—	0.033	0.018	0.035
Cu. Ft. of Gas per Sq. Ft. of Radiation for June, 1931	0.19	0.67	0.96	—	—	4.61	2.50	4.90

(See Footnote, Page 90)

	Buffalo	Birmingham	Indianapolis	Memphis	Des Moines	Kansas City	Louisville	Galveston
Degree Days	69	0	22	0	16	0	13	0
Total for Season 1930-31	6555	2921	5352	3267	5677	4562	4596	1402
Lb. of Coal per Sq. Ft. of Radiation for June, 1931	0.55	—	0.18	—	0.13	—	0.10	—
Gal. of Oil per Sq. Ft. of Radiation for June, 1931	0.047	—	0.015	—	0.011	—	0.009	—
Cu. Ft. of Gas per Sq. Ft. of Radiation for June, 1931	6.62	—	2.11	—	1.54	—	1.25	—

(See Footnote, Page 90)

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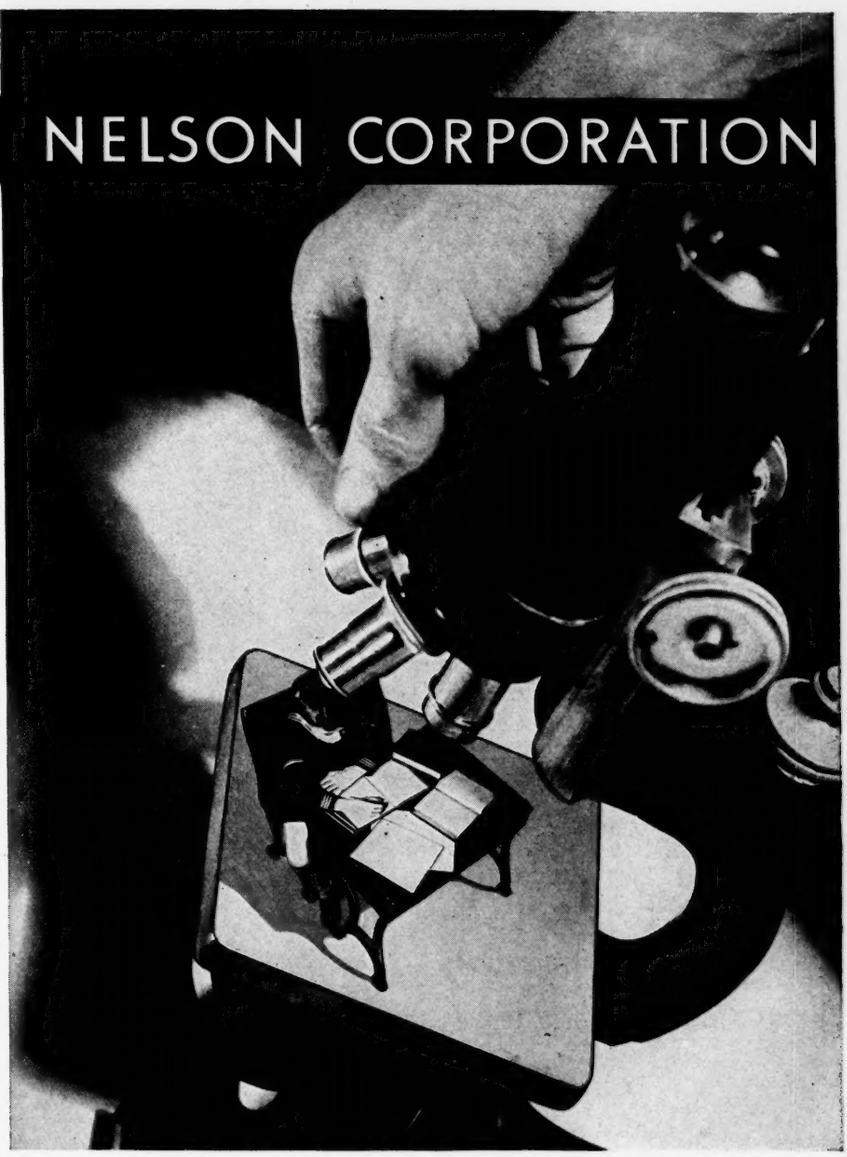
T. H. N. Corp.

THE HERMAN NELSON CORPORATION



HERMAN NELSON

HER-NEL-CO

SYSTEM OF VENTILATION

The Herman Nelson Corporation are makers of the *Univent System of Ventilation*, the *Her-Nel-Co System of Ventilation*, the *Herman Nelson Invisible Radiator*, the *Herman Nelson hi-Jet Heater*, and other heating and ventilating equipment.

For many years science has recognized that the most important factors in ventilation are temperature, air motion, and humidity. But nothing was done about it. Ventilating systems continued to be based on the assumption that it was necessary to supply outside air continuously to the schoolroom. This, of course, raised fuel costs excessively and necessitated the use of large boilers.

Today, however, even better ventilation may be obtained at much less cost. The Her-Nel-Co Ventilator only uses outside air when necessary and in amounts required to remove excess body heat and odors. The outdoor air that is admitted is not preheated, but is tempered through intermixture with room air.

School authorities, engineers, and architects are invited to write for the book, "The Her-Nel-Co System of Ventilation". It shows how schools may obtain better ventilation with a saving of 50% in fuel cost, and a definite lowering of building costs.

A HERMAN NELSON PRODUCT

Factory at Moline, Illinois • *Sales and Service Offices in All Principal Cities*

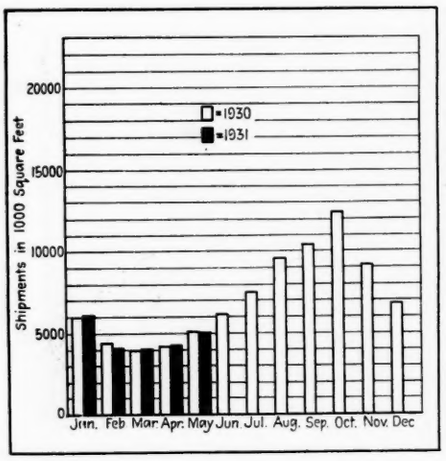
BELFAST, ME.	SCRANTON	GRAND RAPIDS	DES MOINES	MIAMI	SAN FRANCISCO
BOSTON	KINGSTON, PA.	SAGINAW, MICH.	MILWAUKEE	DALLAS	LOS ANGELES
SPRINGFIELD, MASS.	HARRISBURG	DETROIT	APPLETON, WIS.	OMAHA	VANCOUVER, B. C.
PROVIDENCE, R. I.	PITTSBURGH	CLEVELAND	MINNEAPOLIS	EMPORIA, KAN.	TORONTO, ONT.
HARTFORD, CONN.	JOHNSTOWN, PA.	COLUMBUS	DULUTH	KANSAS CITY	WINNIPEG, MAN.
NEW YORK CITY	ALLENTOWN, PA.	CINCINNATI	ST. LOUIS	DENVER	CALGARY, ALTA.
SYRACUSE	ERIE, PA.	TOLEDO	BIRMINGHAM	SALT LAKE CITY	LONDON
ALBANY	WHEELING, W. VA.	INDIANAPOLIS	NASHVILLE	BUTTE, MONT.	OSLO
ROCHESTER	WASHINGTON, D. C.	EVANSVILLE, IND.	CHATTANOOGA	SPOKANE	MELBOURNE
BUFFALO	BALTIMORE, MD.	CHICAGO	MEMPHIS	PORTLAND, ORE.	TOKIO, OSAKA
PHILADELPHIA	CHARLOTTE, N. C.	PEORIA, ILL.	NEW ORLEANS	SEATTLE	BUENOS AIRES

Statistical Service

PRODUCTION data published by the Department of Commerce for April and May are encouraging in the respect that in four of the six items listed below the decrease over last year is less for the last month reported than for the accumulative total for the year as compared with the same period last year.

Of the two items excepted one of these, cast iron radiators, is less than 1% behind the same period last year.

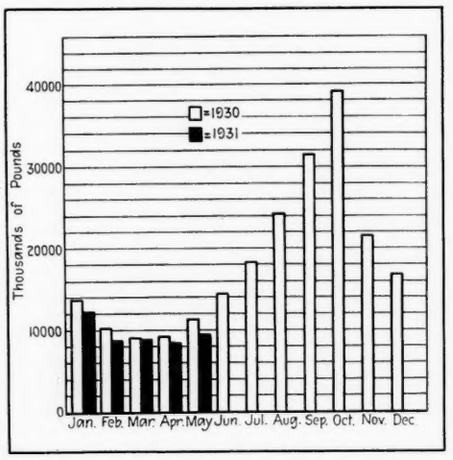
Oil burners have shown a considerable pick-up since the first of the year, April's total being only 5% behind the same month last year, whereas the total for the four months is 15% behind that of last year.



Shipments of Cast Iron Radiators

In 1000 Square Feet

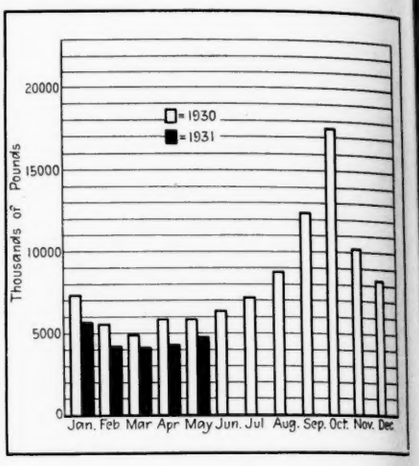
May, 1931, 5,003; May, 1930, 5,047; decrease over last year, 0.85%; total, five months, 1931, 23,500; total, five months, 1930, 23,698; decrease over last year, 0.83%.



Shipments of Cast Iron Square Boilers

In Thousands of Pounds

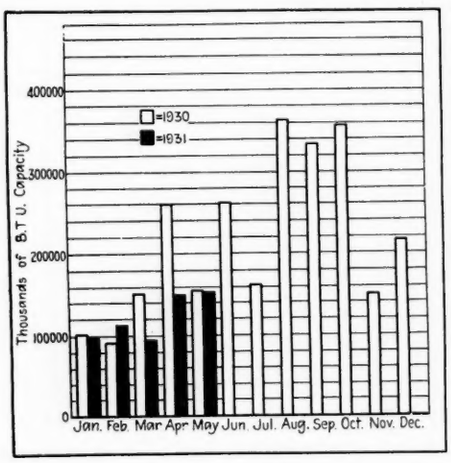
May, 1931, 9,537; May, 1930, 11,249; decrease over last year, 15.2%; total, five months, 1931, 47,550; total, five months, 1930, 53,563; decrease over year, 11.2%.



Shipments of Cast Iron Round Boilers

In Thousands of Pounds

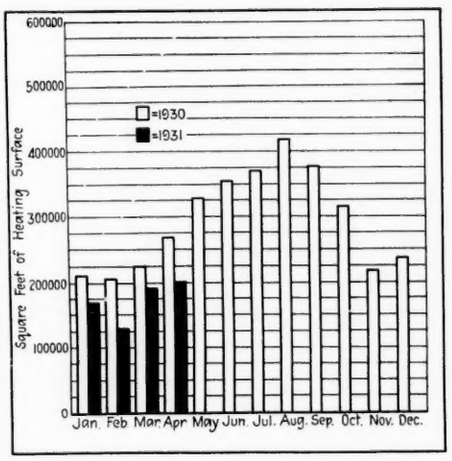
May, 1931, 4,787; May, 1930, 5,898; decrease over last year, 18.9%; total, five months, 1931, 22,997; total, five months, 1930, 29,506; decrease over last year, 22.0%.



Shipments of Gas-Fired Boilers

In Thousands of B.t.u. Capacity

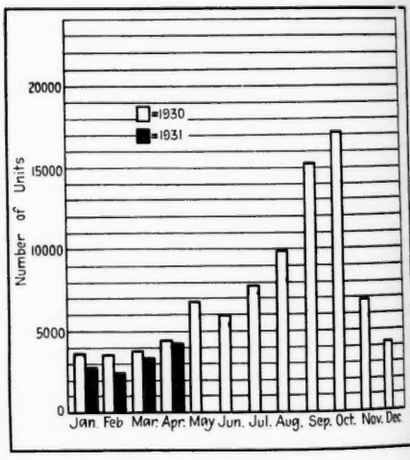
May, 1931, 154,650; May, 1930, 155,282; decrease over last year, 4.1%; total, five months, 1931, 613,632; total, five months, 1930, 757,778; decrease over last year, 19%.



New Orders for Steel Heating Boilers

In Square Feet of Heating Surfaces

April, 1931, 200,321; April, 1930, 271,510; decrease over last year, 26.2%; total, four months, 1931, 689,915; total, four months, 1930, 925,426; decrease over last year, 26.5%.

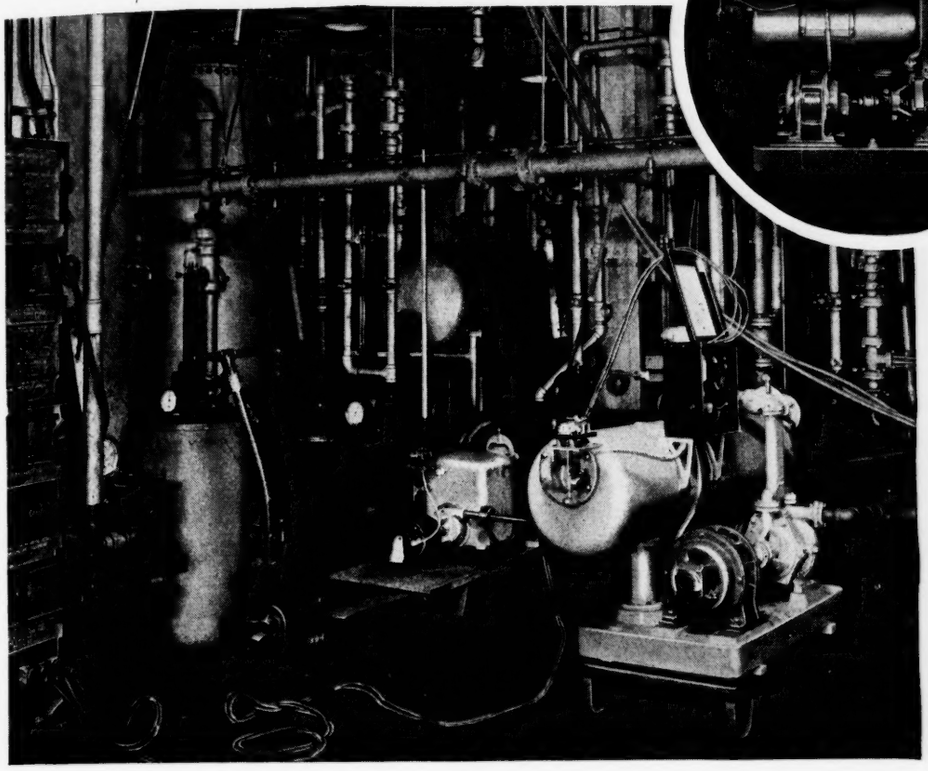


Shipments of Domestic Oil Burne

In Number of Units

April, 1931, 4,203; April, 1930, 4,43 decrease over last year, 5.3%; tot four months, 1931, 12,875; total, fo months, 1930, 15,212; decrease over la year, 15.3%.

This Test Laboratory is your guarantee



Jennings Vacuum Heating Pumps are furnished in capacities of 4 to 400 g. p. m. of water and 3 to 171 cu. ft. per min. of air. For serving up to 300,000 sq. ft. equivalent direct radiation. Write for Bulletin 85.

Laboratory in the Nash factory where Jennings Pumps are tested.

THERE is just one way to make certain that a vacuum heating pump will serve satisfactorily on the system for which it is intended. This is to know, beforehand, the actual measured air and water capacities of the pump.

All guess-work about this important factor is eliminated when you specify a Jennings Vacuum Heating Pump. Jennings published ratings are substantiated in a well-equipped laboratory in which every Jennings Pump is carefully checked before shipment. Air and water capacities are determined by actual tests under working conditions of vacuum and pressure. Each pump is tested as a unit, with its own motor and its own control equipment. This test laboratory is your guarantee of good heating pump performance.

Jennings Pumps

THE NASH ENGINEERING CO. 81 WILSON ROAD, SOUTH NORWALK, CONN.

With the Manufacturers

Fan Manufacturers Amend Testing Code

A resolution amending the standard test code for disc and propeller fans, centrifugal fans and blowers, was adopted by the National Association of Fan Manufacturers at its meeting held June 18, at the Medinah Athletic Club, Chicago. The American Society of Heating and Ventilating Engineers, as co-author of the code, was requested to approve the revisions, which the society did at its recent summer meeting. The changes were as follows:

Following the paragraph "Exhausting Fans," a new paragraph "Centrifugal Fans with Inlet Boxes" was inserted, as follows:

Centrifugal fans with inlet boxes shall be tested with inlet boxes in place. A duct (or ducts for double inlet fans) of the same size and form as the inlet box opening shall be connected thereto, as shown on Plate G. The inlet test duct shall be not less in length than the mean of its two sides. The open end shall be provided with a nozzle inlet formed of cylindrical sides curved to a radius of not less than one-half of the short dimension of the duct, and not less than a 75° arc. Readings shall be taken in said test duct at a point one-half of a mean side from the open and exclusive of the length of the nozzle. The readings are to be taken in accordance with Plate G and the calculations made in accordance with the calculation sheet for Centrifugal Fans Exhausting. See Plates A, B and C.

Ratings based on such tests shall be clearly stated as applying to "Centrifugal Fans with Inlet Boxes" and include the loss in the boxes.

On page 9 of the code, paragraph "Exhausting Fans" ninth line, an asterisk was placed after the word "adding" with the following footnote to which it refers:

This addition is algebraic if, instead of calculated absolute pressures, observed readings are used, those below atmospheric pressure being negative, those above atmospheric pressure positive and the velocity head always positive.

On page 10, paragraph "Disc and Propeller Fan Tests" under the subheading "Test Setup" fourth paragraph in the last sentence, the word "static" was omitted. The revised form of this reads:

The pressure in the large chamber shall be determined by the reading of an impact tube, see Plate B.

Purchasing Agents Propose Uniform Markings on Valves and Fittings

Difficulties and sometimes serious accidents resulting from lack of uniform markings, or entire absence of markings, on valves and fittings have prompted the National Association of Purchasing Agents to establish a committee whose object will be to develop uniform markings and promote their general adoption by manufacturers. The work is under the chairmanship of E. H. Weaver.

In the oil fields particularly, where valves and fittings are used several times, lack of uniform markings becomes a serious problem because of inability to identify pressures, but all other users of valves and fittings are more or less handicapped. The difficulties arise from confusion as to pressures, some valves showing safe working pressures, others test pressures, and some show steam pressures while others apply to oil, water and gas. In some cases casting numbers are shown.

The recent use of various alloys in valve manufacture adds another reason for confusion, for users cannot properly identify the valves when ordering new parts or replacements. Stores department officials experience confusion in stocks and records because of lack of uniform markings.

Universal Sales Co., 154 Middlesex Road, Rochester, N. Y., manufacturers of automatic adjusting radiator hangers, announces the appointment of Stanley Sales Co., 1440 Broadway, New York, as its exclusive eastern sales representative.

Penn Electric Switch Co., Heat Control Division, Des Moines, Ia., has appointed Ben L. Boalt, formerly secretary of the Minneapolis-Honeywell Regulator Company, as its director of sales.

Buffalo Pumps, Inc., is now the new name of the Buffalo Steam Pump Co., Buffalo, N. Y.

Armstrong Cork Co., Lancaster, Pa., has consolidated all its Cincinnati branch sales offices and warehouses at 232 West Seventh Street.

The Automatic Florzone Heating Co., Conshohocken, Pa., has recently been organized to manufacture a line of radiators and gas-fired heating boilers for steam and hot water installations. R. C. Bolsinger is the president of the new company.

Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., has issued a bulletin describing the results obtained from, the construction of, and the applications of the company's Modustat automatic orifice system of individual room temperature control and the Modutrol system of air conditioning control. The book is written in an easily understood style and the appearance is strikingly attractive. Size 8½ in. x 11 in. pp. 32.

Barnes Mfg. Co., Mansfield, Ohio, and *Columbia Radiator Co.*, McKeesport, Pa., announce the opening of a joint warehouse at 39th and Wallace Streets, Chicago. Frank Barry has been appointed district manager.

Federal Radiator Co., Zanesville, Ohio, has recently opened a branch office and warehouse at 4524 Lakeside Ave., Cleveland, Ohio, and a branch office in the Building Industries Bldg., Cincinnati.

Chicago Pump Co., 2326 Wolfram St., Chicago, has published Bulletin 137, covering the Condo-Vac return line vacuum and boiler feed pump. Illustrations include colored sections of the pump which aid in understanding the operation of the unit, while blue prints show typical connections. An unusual and valuable idea incorporated in the bulletin is that of showing on loose sheets plan views of the various models to ¼ in. scale so that the engineer can trace the plan on his drawing in a short time. Size 8½ in. x 11 in.

Announcement of the New WING Featherweight Unit Heaters with the New Featherfin Heating Element . . . *Completely described in the 16-page Wing catalogue filed in Sweet's Engineering Catalogues 1931 Edition*

L. J. WING MFG. CO. NEW YORK, U. S. A.

THE NEW WING FEATHERFIN HEATING ELEMENT

(Tested to 1000 Lbs. Pressure)

THE new Wing Featherfin heating element has been developed after years of study and experimentation with a view to extending the use of Wing Featherweight Unit Heaters to plants that do not have low pressure steam available. In designing this heating element, there were two primary considerations: the first being weight, and the second, a uniform design that would be applicable to high as well as low pressure, and which would permit varying the arrangement of the heating surface, thereby producing any desired final temperature, regardless of the pressure of the steam.

These points are fully realized in the new Featherfin heating element. It is lighter, in fact, than our original low pressure element, and by simple variations of the assembly of the heating surface any desired final air temperature may be obtained with any given steam pressure.

Low Final Temperatures with High Steam Pressures—Unit heating with high pressure steam has not heretofore been entirely successful due to the fact that the same arrangement of heating surface has been used for high pressure steam as for low—the result being that with high pressure steam, the air discharged by the heater is too hot and the volume too small. From knowledge gained by years of experience with the old central fan system of heating, it is a well established fact that successful unit heating requires the circulation of large volumes of air at relatively low temperatures.

Therefore assemblies of the new Featherfin heating element have been standardized for steam pressures of 5, 40, 70, 100 and 130 pounds all producing the same low final air temperature.

DETAILS OF CONSTRUCTION

The new Featherfin heating element is of the fin and tube extended surface type. Careful attention has been given to the elimination of expansion and contraction strains. The finned tubes being of hairpin, or return bend design, are free to expand and contract individually without danger of damaging the header connections or the adjacent tubes.

The Finned Tubes—The tubes are of seamless drawn copper. Perfectly flat oblong fins, arranged with their greatest dimension in the direction of air flow, are forced onto the tubes and properly spaced by automatic machinery. Being perfectly flat and free from crimping and corrugations, the fins offer minimum resistance to the air flow, and do not catch and hold dirt, the accumulation of which will greatly reduce the efficiency of any heater. In punching the tube hole in the fins, collars are formed which make a perfect thermal contact with the tubes, but to insure permanence of contact, each finished tube is dipped in a bonding alloy having a melting point nearly twice the temperature of steam at 120 pounds pressure.

Steam and Return Headers—Headers are of steel, tubular in design. A flat surface is provided for drilling and machining for the reception of the tubes. A heavy plate is welded to each end of the headers for securing the heating element to the heater casing assembly.

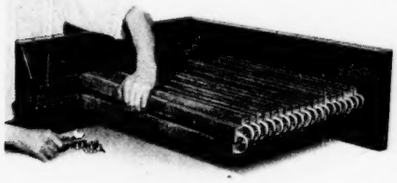
Header-Tube Connection—The tubes are secured to the headers by a mechanical joint consisting of a compression union comprising a brass ferrule and a nut. The brass ferrule is first placed in the recessed hole in the header, and the nut screwed in lightly behind it. The tubes are then inserted and the nut screwed down tightly. So great is the pressure put on the ferrule in tightening the nut, that two deep rings or grooves are pressed into the tubes, one at each end of the ferrule (see detail), making a positive steam joint. Yet at the same time it is possible to remove and replace any of the tubes in the event of damage by accident.

Assembly in Heater Casing—The heater element is firmly secured in the heater casing at the header end by the heavy key plate previously described. The tube ends are supported and held secure against vibration by a channel shaped retainer of heavy sheet metal, small spacer blocks of especially treated asbestos being inserted in the retainer between each tube.

Test—Regardless of the steam pressure with which it is to be used, each heater upon completion is given a steam test of at least 150 pounds, and subjected to a hydrostatic pressure of 1000 pounds.

THE FAN WHEEL

The fan wheel used in the Wing Featherweight Unit Heater is the well-known Wing Scruplex Propeller Fan, recognized for its ability to deliver air at high velocities and against high static pressures. It has contributed in no small degree to the ability of the Wing Featherweight Unit Heater to project heated air to the working level from great heights.



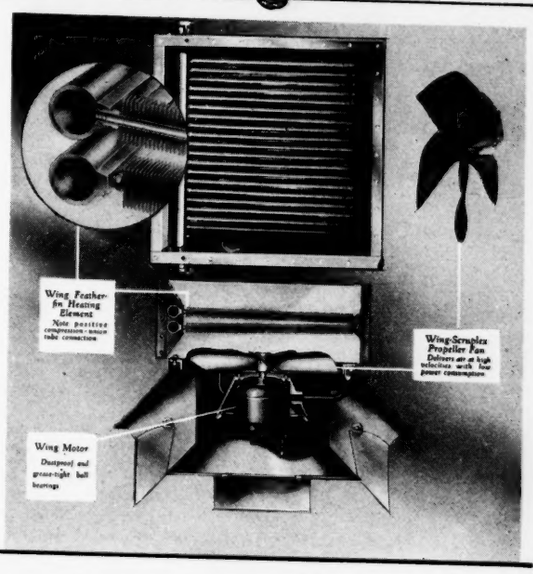
This photograph illustrates the assembly of the hairpin tubes into the headers.

The brass ferrules shown are placed into the recessed holes machined in the headers, the nuts also shown are screwed in lightly behind them. The tubes are then inserted and the nuts screwed down tightly. So great is the pressure on the ferrule in tightening the nut that two deep rings or grooves are pressed into the tubes, one on each end of the ferrule. (See detail on following page.)

Note particularly the ease with which tubes may be moved and replaced in case of damage by accident.

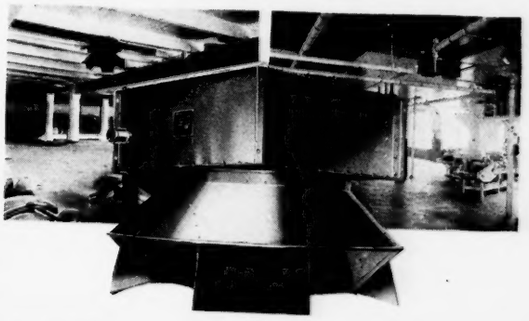
[8]

WING FEATHERWEIGHT UNIT HEATERS


Wing Featherfin Heating Element
Note positive compression-union tube connection
Wing Scruplex Propeller Fan
Delivers air at high velocities with low power consumption
Wing Motor
Dustproof and grease-tight ball bearings

L. J. WING MFG. CO. NEW YORK, U. S. A.

TYPE LC



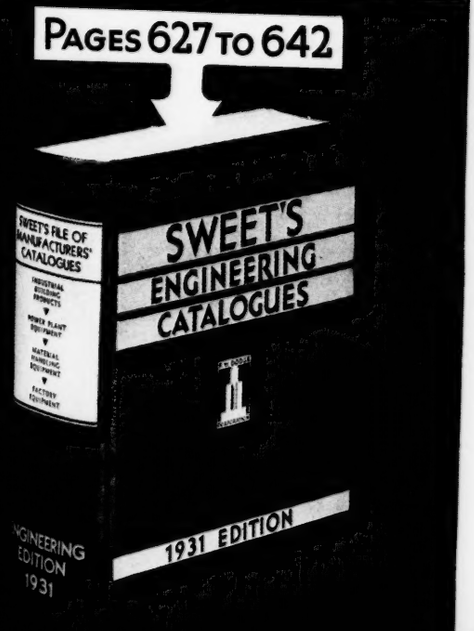
Type LC Heater without Discharge Outlet

Type LC Heaters are used where the ceiling or roof is relatively low and when, consequently, it is necessary to keep pipe lines close to the ceiling. This type is also best for use when outside-fresh-air is to be supplied to the building by the heater, since the fresh air duct may be very easily connected to the intake at the top of the heater, the motor remaining fully accessible from below (see illustration on page 19). Page 14 also illustrates a heater especially designed for this purpose that permits of controlling the temperature of the air supplied to the building.

DIMENSIONS

Size	A	B	C	D	E	F Steam 0 to 40 lb.	F Steam 40 lb. up	G Return 0 to 40 lb.	G Return 40 lb. up	H	J	K	L	M	P	R
13-LC	16	16	8	2⅝	4⅝	one 1¼	one 1¼	one 1¼	one 1¼	20	6	1	18⅛	23	12	2⅝
17-LC	19⅝	19⅝	8	1½	3⅝	one 1¼	one 1¼	one 1¼	one 1¼	20	6	1	21⅝	27	12	2⅝
19-LC	22⅝	22⅝	9	1½	3½	one 1¼	one 1¼	one 1¼	one 1¼	20	6	2⅜	25⅛	29	12	2⅝
23-LC	27⅛	27⅛	9	1½	3½	one 1¼	one 1¼	one 1¼	one 1¼	21	6	2⅜	27	30	12	3
28-LC	32⅝	32⅝	9	1½	3¼	one 2	one 1½	one 1¼	one 1¼	22½	6	2⅜	27	30	12	3
38-LC	32⅝	32⅝	9	1½	4	one 2	one 1½	one 1½	one 1½	22½	6	2⅜	31	38	13½	3½
46-LC	39⅛	39⅛	12	2⅜	5	one 2½	one 2	one 2	one 2	25½	7	2⅜	34	46	16¼	4
54-LC	45½	45½	12	2	5½	two 2	one 2	two 2	one 2	25½	8	3½	39	54	20	4½
										30½	8	3½	39	64½	23½	5½

[81]



J. WING MFG. CO. DEPT. 8 [illegible] W. 14th St. NEW YORK, N.Y.